# Sustaining Malaysia's Future

The Mega Science Agenda

AKADEMI SAINS MALAYSIA

Energy

# A MEGA SCIENCE FRAMEWORK FOR SUSTAINED NATIONAL DEVELOPMENT (2011 – 2050)

## EPILOGUE

### 1. Introduction

Science has been universally touted as the main engine of economic growth and national development. Science from its Latin name 'scienta' means knowledge. A knowledge-based economy is essentially a science-based economy. New knowledge i.e. "science" is generated by undertaking research, experiments and strategic studies or R&D. R & D and strategic studies provide the means to fulfill market needs and find solutions to various problems. The results and findings are delivered in the form of new or enhanced knowledge, technology and products or services. This results in productive economic activities which contribute to wealth creation and economic growth.

Malaysia, as a country, should adopt the concept of a Mega-Science Framework as a comprehensive vehicle to drive the use of science, technology and innovation (STI) to contribute towards economic growth. Mega essentially means big, therefore the discipline of Mega-Science implies a pervasive (broad-based), intensive (in-depth), and extensive (long period of engagement) use of science or knowledge to produce technologies, products and services for all sectors of the economy to derive economic growth and development. It also calls for extensive investment in research activities to enhance the knowledge base for the targeted sectors. Since knowledge in marketing and finance is equally important in promoting the success of a commercial venture as compared to technical needs, it is envisaged that the Mega-Science approach will require research to be conducted both in non-technical sectors as well as in traditional scientific sectors.

### 2. A need for national knowledge generating mechanism

As we are aware, national economies are classified into 5 sectors namely: agriculture, mining, manufacturing, construction and services (Table 1). Efforts to generate knowledge by establishing research institutions and universities and centers of excellence to support agricultural, mining and manufacturing sectors are well established. The construction and services sectors are also dependent on new knowledge and technology in order to progress and remain competitive. R & D and strategic studies are also necessary to drive the development of these two sectors.

**Table 1 NATIONAL ECONOMIC SECTORS (% OF GDP)**

| SECTOR | 2010* | 2015** |
|---|---|---|
| SERVICES | 58.5 | 61.1 |
| AGRICULTURE | 7.6 | 6.6 |
| MINING | 7.9 | 5.9 |
| MANUFACTURING | 26.2 | 26.3 |
| CONSTRUCTION | 3.2 | 2.9 |

*Source:*Economic Report 2009/2010 (MoF)*
***RMK10 Report (EPU)*

The Mega-Science approach would emphasize the need to strengthen R & D and strategic studies to be undertaken in these non- traditional sectors. For example, to enhance the development of the tourism industry (service sector), dedicated R&D and strategic studies should be undertaken to generate new knowledge that will lead to the delivery of new tourism products, services and innovative strategies which will improve competitiveness of the industry. Similarly, research studies, market surveys and financial models are proposed especially for the services sector as the knowledge created will fulfill a need or solve a problem which eventually will generate revenue and contribute to economic growth. The Mega Science approach therefore identifies R&D and strategic studies as the key enablers to economic growth in all targeted sectors of the economy.

### 3. A need to invest sufficiently in knowledge creation: R & D and knowledge acquisition

To become a high income developed economy, Malaysia as a country has to intensify knowledge generating capacity by investing in R&D and strategic studies. The expenditure in R & D must reflect the norm usually associated with countries having a developed economy. While past expenditure in R & D for Malaysia as a developing country has hovered at 0.5% of the national GDP, the present and future rate of spending should be increased to above 2.0% as benchmarked against the rate of spending for countries with developed economies (Figure 1). Towards achieving this goal, it is proposed that the Government formalize the rate of spending of 2% and above through the promulgation of a Science and Technology Act ("S&T Act"), which is long overdue.

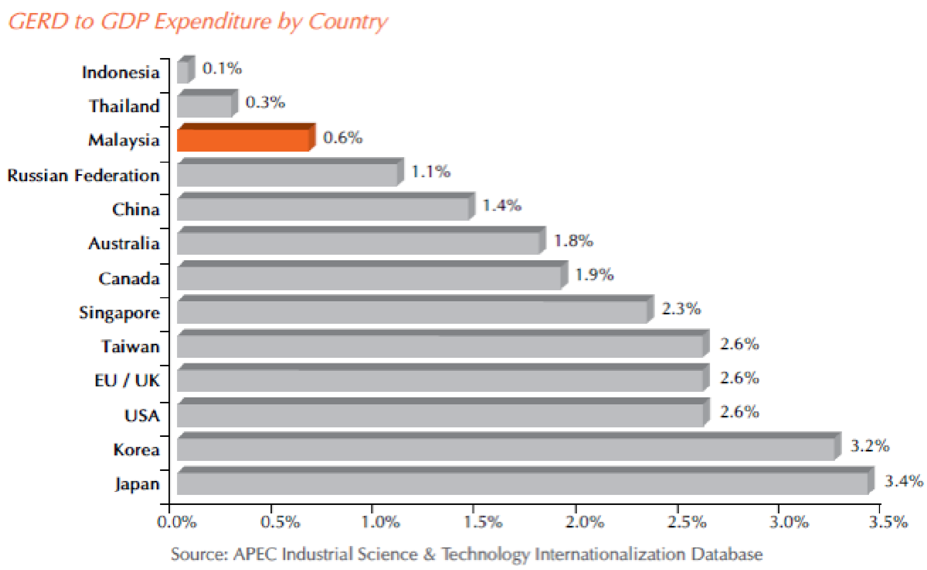


***Figure 1 Malaysia's Low R&D Investment***

R&D needs a long lead time before beneficial results can be harnessed to contribute to the economy through commercialization of research results and development of expertise (Figure 2). To fulfill the need to have pervasive, intensive and extensive R&D activities and satisfy the long lead time needed for R&D to mature, bold up front investments in R&D spending will be necessary. While this is financially difficult to reconcile, extensive and expensive upfront investment in R & D is necessary and forms a critical dimension of the Mega-Science Framework approach. These long lead times from R&D to Commercialization are amply demonstrated in Malaysia in the rubber and palm oil sectors of agriculture. In rubber, we took some 50 years to see Malaysia "topping the world" in rubber technology since initiating R&D in rubber. Similarly, in palm oil, Malaysia took about 40 years to "top the world".

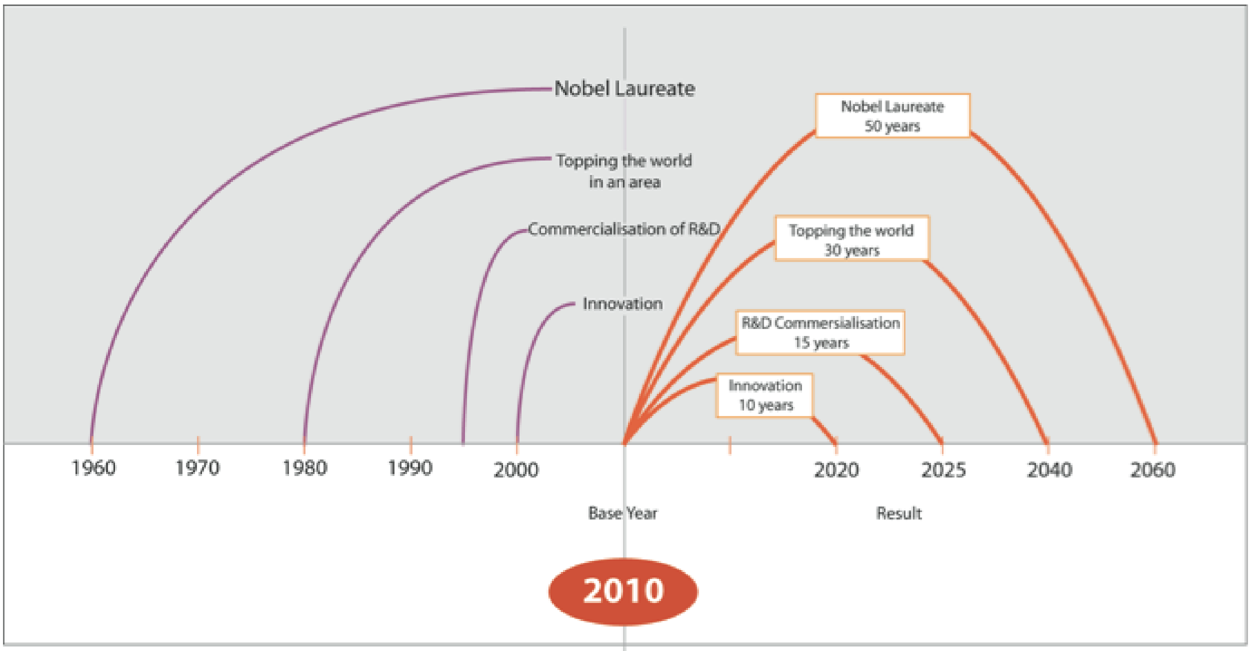


***Figure 2 Time Lag on Increase in HR and R&D Investments and the Resultant Key Indicators Stimulating Economic Growth***

Although a certain amount of knowledge, technology and research inputs may be imported especially through FDI activities, these are often out-dated or out-of-sync with business and economic needs. Therefore, the process of knowledge renewal and enhancement must continue to be undertaken for the country to remain competitive.

**4. A need to manage knowledge generation and acquisition nationally through private and public sector participation**

The Mega-Science Framework looks at national efforts in generating new knowledge and STI deliverables. The country's science infrastructure must exist to help deliver the desired results. The science infrastructure should also ensure the evolution of more R&D to be undertaken by the private sector vis-à-vis the public sector as is typically found in a developed country economy.

The present proposal to establish the National Research Council (NRC) and the National Innovation Unit (UNIK) should be encouraged as these provide the management function of ensuring that funding and management for R & D and strategic studies will be maximized. A significant role of ensuring the timely development and availability of STI deliverables for economic growth must be emphasized. In this respect, the role of MIGHT and other Technology Development Corporations in technology foresight scoping, development and acquisition are highly crucial especially bearing in mind that some technologies can be obtained through offset programmes of government international tenders.

## 5. Knowledge gaps in various economic sectors

In the past, economic growth was a function of knowledge (technology) and capital accumulation. Past investments in R&D in the relevant sectors would have generated knowledge to stimulate economic growth. Continuous knowledge enhancement (training) or accumulation of human capital development (expertise) adds to facilitate and accelerate economic growth. The serious lack of researchers in basic and applied sciences has to be urgently addressed such that it does not hamper the generation of knowledge and hamper sustained economic growth of the nation (Figure 3).

Future economic growth may be limited by natural limits to growth effected by population growth and excessive demand for non-sustainable and non-renewable resources. There is the possibility of reaching limits of environmental carrying capacity. Therefore, future economic development may not only depend on accumulation of capital and technology, but also on natural resources including energy and land, and the carrying capacity of the environment. These additional factors of economic growth must be factored in to the future development of the country's economy.

*Full Time Equivalent (FTE) Researchers per ten thousand Populations / Workforce by Country*

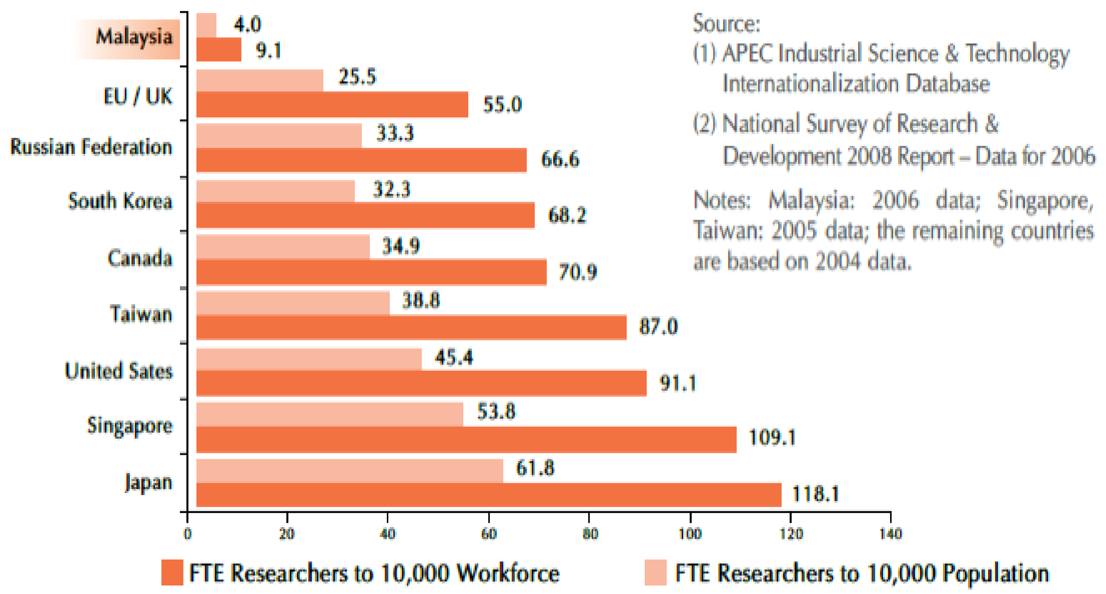


***Figure 3 Low FTE Researchers – A Barrier to Sustained Economic Growth***

To sustain future economic growth in Malaysia, investment in knowledge creation must be continued or enlarged. The knowledge creation (R&D) function of the Mega-Science Framework will rightly identify and address these needs.

## 6. Malaysia needs to intensify knowledge generation in niche sectors

Part of the Mega-Science Framework calls for pervasive, intensive and extensive use of science to identify and develop competitive knowledge and STI opportunities for commercialization in various sectors of the economy. Subsequently, another part of the Mega-Science Framework will require prioritizing of sub-sectors so that returns to strategic R&D investments are maximized. This will naturally lead to more efforts being devoted to developing of niche key sectors where Malaysia has certain competitive advantages.

Identification of the niche sub-sectors may employ the process of consultation and short term evaluation of opportunities such as the "laboratory retreats" studies undertaken by the Malaysian government recently. In addition, long term development of niche areas at the national level and the private sector will be necessary. The process is iterative. The more the investment in knowledge (R&D and STI development) the more will be the discovery of niche areas for commercial exploitation where Malaysia has the competitive advantage. But in-depth knowledge developed through the Mega-Science Framework is firstly needed to identify the niche areas.

## 7. Sectoral knowledge gaps and STI requirements

Studies of various economic sectors have identified the need to invest in knowledge gaps to sustain current and future needs, maintain competitiveness and contribute to the country's economic development. Firstly, cost must be kept optimally low and secondly revenue must be maximized. Ideally, the sector will generate enough commercial revenue to cross-subsidise the need to maintain the sector at minimal cost. For example, in the health and medical sector, knowledge enhancement is continuously needed to maintain the capacity of the sector to provide a high standard of health service. Efforts include promotion of preventive activities which will reduce health treatment in the long run. But there are also opportunities to generate revenue by supplying and exporting competitive health services and products such as health tourism which can contribute directly to economic growth. Similarly, in the Water Sector, ASM's Mega Science Study has identified opportunities in S&T in various niche areas.

In the biodiversity, energy and agricultural sectors which have been subjected to the Mega-Science Framework Studies undertaken by the Academy of Sciences Malaysia (ASM), it was found that the knowledge creation and STI application opportunities and gaps exist in both the home consumption and exportable components of each sector. The defense sector could similarly fall into the two categories of development, and as more economic sub-sectors are evaluated in the future under the Mega-Science Framework Studies, the pattern will probably be the same: the need to develop both the home consumption and exportable components of the sector in order to improve the country's standard of living directly and to generate revenue for increased income.

Examples of gaps in STI adequacy and niche opportunities have been identified during the Mega-Science Framework Studies undertaken by the ASM recently. The examples clearly show that Malaysia has many niche areas for STI development for commercial exploitation especially for the export component. It is also noted that a sector with well developed export component will also provide for adequate home consumption needs. It implies that developing the export component of a sector should be given greater focus and priority as this will serve to also develop the home consumption sector to bring about improved standard of living while increasing revenue and income.

## 8. Lubricating the Engine of Growth

The Mega-Science Framework advocates the pervasive use of knowledge and proposes the use of STI as the main engine of economic growth and national development. An engine does not function without lubrication. To facilitate the smooth or lubricated functioning of STI, human resource expertise must be adequately available. Fortunately, the enhancement of expertise of human resource is achieved through the same engagement in knowledge creation process (R&D) and other forms of knowledge enhancement process (training) at universities, research institutes and training centers. The more people are involved in R&D and STI development; the better will be the available expertise of the country. R&D investments therefore contribute to expertise and knowledge enhancement of human resource.

Another dimension of the lubrication process to the engine of growth is the level of income itself. There exists an iterative cycle in the relationship between intensity in investment in R&D and the level of income of the country. The higher the R&D expenditure the higher will be the income level. The higher the income level, the higher will be the R&D expenditure. To break this vicious cycle, it is necessary to adopt a strategy of a high income economy, similar to what the country is currently attempting to do. In the past, Malaysia has adopted a low income and low cost economy with a reasonably high purchasing power parity index compared to other countries. It was found that the low income and low cost economy has severe limitations to promote further growth and consequently, Malaysia was led into the middle income trap. Low income strategies do not attract talents and retention of expertise in the country. Low income strategies also under-exploit the services sector which now becomes a major sector of the economy. Services provided in Malaysia earn much lower revenue compared to similar services provided by the developed economy countries.

High income economy means high salary which means high costs. Malaysia must be prepared to adopt a high income and high cost economy as this is the norm seen in other developed countries. High cost is inevitable because when looked from the income side, high income means high salary, but the same high salary will mean high cost when looked at from the cost perspective. The big advantage of high income and high cost (salary) economy is that expertise is easier to obtain and retain, and in addition, the services sector such as hotels, tourism, banking, airlines, etc will be charging internationally competitive prices to maximize revenue and income for the country. Furthermore, efficiency will automatically be enhanced when an economy operates on a high income and high cost strategy. Such an economy will also be able to pay international prices and avoid most subsidies. The billions of Ringgit of subsidy money currently provided in the government budget can instead be distributed to increase salary. Leaving it to the high income individuals to buy the unsubsidized goods and services will further improve efficiency and reduce wastages which are often encountered in a subsidized economy.

## 9. S&T Governance

In Malaysia, Science, Technology and Innovation are being given very high priority. However, Academics and Researchers need to play a very strong role in evidence- and data-based decision-making, while bureaucrats should continue to play a supporting role.

In the Korean example, a high-level National S&T Council, chaired by the President with the Minister of Environment, Science and Technology as the Vice-Chair and the Ministry of Environment, Science and Technology as the Secretariat, has 5 Committees (Figure 4) on Key Industrial Technologies, Large-Scale Technologies, State-led Technologies, Cutting Edge and Convergence Interdisciplinary Technologies and Infrastructure Technologies.

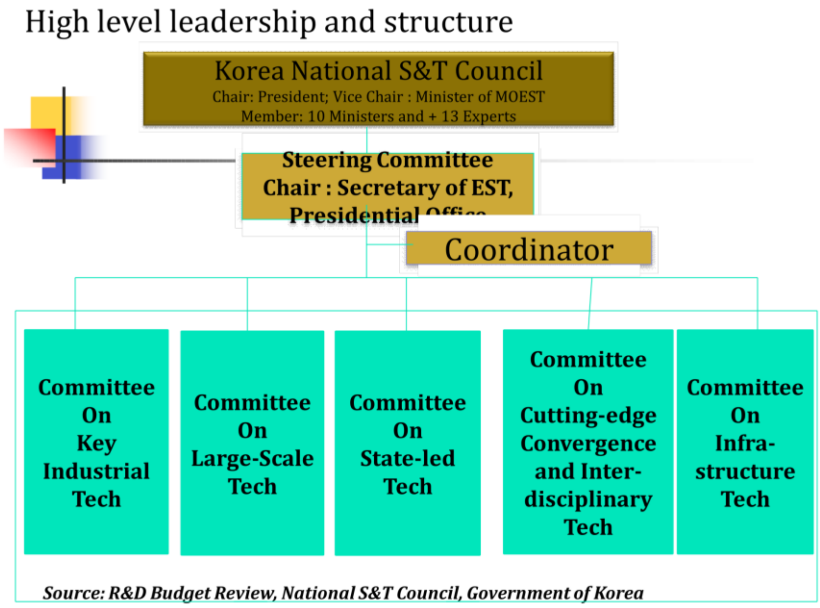


*Figure 4 Korean National S&T Council*

## 10. Funding

Malaysia is in the process of improving its science infrastructure to help improve the capacity of the country to use science (STI) as the main engine of growth for its future development. Funding and investment in R&D and strategic studies in all sectors of the economy remain underdeveloped. Such funding is both important and urgent because of the long lead time needed to provide future STI deliverables.

It is proposed that Malaysia makes a 'jump start' and allocates RM 20 billion for an accelerated development of its science industry between now and the year 2020. This fund should be managed by the responsible agencies to ensure both priorities in R&D and strategic studies and the intensification of R&D especially in the private sector can be implemented. Such funding should be increased if necessary during the period of implementation. Commitment to fund the science industry with a RM 20 billion grant would greatly contribute to the achievement of the high income economy strategy as proposed by the government. In comparison, many other countries, both developed and developing, are already providing such mega science grants to invest for their sustained growth in the future. As an example, the Korean Government gave an allocation amounting to US$16 billion to facilitate the R&D programme in the country. UNIK can be authorized to manage, coordinate, distribute and monitor the RM20 billion grant.

As a second option, part of the RM20 billion grant can be created from taxing corporate profits, amounting from ½% to 2%. The corporations will however be exempted from this taxation if they can show that they are undertaking R&D. UNIK can be authorized to verify and certify that the R&D is being carried out. The exemption will be given to corporations able to show that they are undertaking R&D, Strategic Studies and/or undertaking technological acquisitions to further their R&D capacity and capability. In this way, more R&D, of at least 75%, will be carried out by the private sector.

In essence, the following actions are proposed as part of the functions of UNIK which will be authorized to manage, coordinate, distribute and monitor the grant:

(i) Raise R&D funding, amounting to 2% and above of GDP, through the Government initially giving a "launching grant" amounting to RM 20 billion. The grant can be sustained through taxing corporate profits, amounting from ½% to 2% with the necessary tax exemptions given as described above;

(ii) Prioritise R&D areas with advice from the National Science Research Council; and

(iii) Migrate to improving the R&D activities to be mainly private-sector driven with the ratio being private sector: public sector at 75%:25%.

## 11. Conclusion

A Mega-Science Framework can be the national vehicle to promote the application of knowledge (science) through STI commercialization to generate better standard of living and new sources of revenue and income to achieve economic growth and national development. The advocacy of science (STI) as an engine of growth can be reinforced through the strong recognition given via the Mega-Science Approach on the need to have extensive investment in R&D and other strategic studies in both traditional 'scientific' sectors and the newly-emphasized services sector.

The scientific STI system as an engine of growth can be further 'lubricated' to deliver the end objectives by the adoption of knowledge enhancement strategies through R&D and training, as well as the adoption of a high income and high cost economic system as practiced by other developed economy countries. By systematically evaluating the knowledge and technology gaps in various sectors and sub-sectors of the economy, it is possible to provide the country with a road map of future opportunities in STI implementation for economic growth and national development. Present studies show many fertile areas of future opportunities exist for the sectors evaluated.

Malaysia's rate of knowledge generation is falling far behind the desired target. It can be concluded that science has not be given the needed funding and urgency to enable it to be truly the engine for sustained national growth for the future. It is hoped that the adoption of a Mega-Science Framework approach will help resolve these limitations and assist in the development of the science industry in the country.

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**President**
**Academy of Sciences Malaysia**

22nd December 2010

## PREFACE

One of the most frequently asked questions by decision-makers and scientists themselves is “How can Science, Technology and Innovations (S, T and I) contribute more effectively to economic development and wellness in a sustained manner without compromising the environment’s sustainability”. There are good reasons to turn to S, T and I because they have a track record to meet critical challenges posed primarily by the growth of human population and their wants. The eradication of small pox by 1979 saved millions of life, the green revolution in the 1960's staved off global famine, nuclear power help to supplement increasing energy demand and the computer enhanced the dissemination of information for education, research and business. Antibiotics and vaccines dramatically increased life spans and improved health all through S, T & I.

Unfortunately, during the past 30 years, the anthropocentric S, T & I approach changed food production, transportation, communications, education, health and even culture (consumption society) which resulted in unsustainable environments including climate change. Designed for efficiency and driven by profit, S, T & I innovated and produced non-biodegradable plastics, toxic DDT, CFC, harmful nuclear wastes and encouraged a new generation of consumption society through automation and mass production - not to mention sophisticated weapons of mass destruction. Today we face the results of "destructive creation" because the innovators failed to factor in the impact on sustainability and wellness.

Once again no doubt, S, T & I will rise to meet the new challenges in response to the national and global demand to factor towards enhancing quality of life in all products, processes, services and development projects. It is now known that there is no positive co-relationship between the rise in GDP and wellness or quality of life. The new awakening of the global community towards a more ecocentric paradigm will change innovations and business. There are already instruments in place such as "eco-labeling" for tropical timber, traceability for food products in EC and green building index in Malaysia.

The biggest challenge to all scientists is how to use the fixed earth resources (especially water, land and minerals) to produce food, water and goods for human needs without depriving habitats for the millions of other species and destroying the ecosystems. Proven existing technologies must continuously be improved to be eco-friendly whilst the emerging one such as renewable energy, genomics, stem cells, nanotechnology, biotechnology and the novo-ICT must conform to the new order of sustainability, ethical and moral obligations whilst contributing to the economic development of the nation.

Malaysia, with its biodiverse wealth, can turn to nature for many of the answers for a developing innovatively (and of course, sustainably) our economy. Scientists only need to uncover them. We need to turn to the sun - a natural nuclear fusion reactor for all our energy needs and to water (rivers and oceans) to provide the additional food needs to begin our new journey towards a sustainable world for all. This journey for Malaysia must begin now.

At the same time, there are vast opportunities in various sectors of the national economy which can be leveraged upon in an attempt to resolve challenges and problems faced by the populace through innovative approaches in the application of Science, Engineering and Technology (SET). Through identifying and developing various tools through SET, it will go towards ensuring that our economy is not only sustained but sustained in a sustainable manner.

The Academy recognizes the importance of cross disciplines linkages that must be integrated during planning, implementation and monitoring of national programs and projects. Social engineering must be designed to match the rapid technical advances to minimize their negative impacts.

In this series, of the Mega Science Framework Studies for Sustained National Development (2011-2050), undertaken by the Academy of Sciences Malaysia, S, T and I opportunities have been identified and roadmaps provided for the short- to long-terms applications of Science, Engineering and Technology in the critical and overarching sectors such as water, energy, health, agriculture and biodiversity.

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Academician Tan Sri Dato' Dr. Ahmad Mustaffa Babjee F.A.Sc (Project Team Director from 1st May 2010 until present)
Dr. Ahmad Ibrahim (Principal Team Member from 1st September 2008 until 31st December 2010)

# EXECUTIVE SUMMARY

## THE STUDY

The "Mega Science Framework Study for Sustained National Development (2011–2050) – The Energy Sector" is one of a number of recently completed or ongoing studies of the energy sector of the Malaysian economy. This study is aimed at identifying (1) energy-related STI opportunities that can contribute to Malaysian economic growth, and (2) what needs to be done to ensure that the country will have the STI resources necessary to take advantage of these opportunities.

The more important of the 'parallel' studies are:

- The Energy Blueprint Study ISIS Malaysia, a report to the Energy Commission Malaysia, July 2008
- Study to Formulate a New Energy Policy for Malaysia (2010-2030), EPU, November 2009
- National Renewable Energy Policy and Action Plan, Ministry of Energy, Green Technology and Water, April 2009
- Progress Report 1; National Energy Efficiency Master Plan Study for the Ministry of Energy, Green Technology and Water, October 2009
- Technology and Alternative Energy, Resource magazine, December, 2009
- Nuclear Regulatory Newsletter, MOSTI/AELB, December 2009
- Presentations by Dr Fereidoon P. Sioshansi, Menlo Energy Economics, Brain Gain Malaysia Programme, December 2009
- Proposal for Renewable Solar Photovoltaic (PV) Energy, Khor Cheng Seong, Universiti Teknologie Petronas (UTP), January 2010
- Report on the Proceedings of the Brainstorming Session on Renewable Energy, MNC/CIGRE Malaysia, and PTM Study on RE, January 2010

The purpose of this *Mega Science Framework Study* has been primarily to identify near-term and longer-term energy-related opportunities in which the application of STI resources (i.e. science, technology, engineering and innovation resources - both human capital and physical assets) could make a material contribution to accelerating the sustainable development of Malaysia. The study also provides a high-level framework that could assist the government to realize these opportunities.

The study results have been derived from:

- a review and analysis of publicly-available information;
- information presented at international conferences and congresses;
- information developed by our experts during their previous and ongoing work in the energy sector;
- information obtained at interviews with senior executives who are knowledgeable in the areas of energy usage and sustainable development in the country; and
- information shared by international experts.

Wherever quantitative information has been included in this Final Report, the values will be merely indicative to give a *feel* for the magnitude of the payoff from the opportunity.

The scope of work given to the study team was as follows.

- To identify sources of future growth opportunities in the various areas of the energy sector (including renewable and alternative sources of energy) including their use in the transportation sector.
- To identify the current gaps in STI knowledge in the energy sector and the areas in which STI can assist in the economic growth of the nation.
- To undertake comparative studies with other countries that will allow the local energy sector to grow, including the identification and development of the policies necessary to sustain this growth.
- To identify and propose appropriate measures in the research needs of the energy sector that can contribute to sustained economic growth.
- To conduct a review on international best practices of STI policies and plans for sustained national development in the energy sector.
- To review and analyze the government's various policies, strategies and plans towards identifying educational (capacity building), technological, scientific and governance (institutional framework) gaps in the energy sector.
- To identify gaps in the research needs of the energy sector and propose appropriate measures to enhance growth potential.
- To propose an action plan for the implementation of the recommendations arising from the study.
- To propose a rollout plan of an energy sector roadmap for implementation of the action plan.

The study team next places on record the three principal recommendations that it believes must be acted upon by the government if the country is to deepen and broaden its STI resource base, have an effective energy-related research programme and realize the benefits of the energy opportunities available now and those that will emerge in the future.

**Recommendation A: The government must form a team of the best technical, policy and business minds to:**

- ***Determine the specific objectives it wants to achieve the goals in the energy sector and the overarching strategy that must be employed to achieve those objectives;***
- ***Review all the recommendations that have been made in the various studies of the energy sector over the last two years and develop a priority ranking for these recommendations based on the degree to which they will contribute to achieving the objectives;***
- ***Develop a preliminary estimate of the available STI resources that can be committed to the most highly ranked recommendations; and***
- ***Develop a roadmap and action plan that can be followed to achieve the objectives.***

This recommendation should be acted upon to completion within a time-frame of 18-24 months. Essentially, the study team is recommending that the government take a step back and carefully evaluate *everything* that has been proposed and recommended before making any further commitments. At present, there does not appear to be any priority order for actions, focus, assessment of programmes and evaluation of results. Worst of all, there is no single-point responsibility. Unless these deficiencies are rectified, the money and energy that is going to be spent on developing the energy sector will largely be wasted. So the team is proposing that the government suspend all decisions that are pending regarding policies and spending until the special review can be completed. When this is done, the government will have a consistent, focused and unified plan of action to guide policy making and investment decisions.

**Recommendation B: The government must establish the processes, methods and motivating mechanisms that will be used to drive the implementation of the energy sector roadmap. This must be carried out in tandem with Recommendation A.**

This is necessary because the implementation process has routinely been the point of failure in Malaysia. The study team is recommending that a careful and critical review of the causes behind the failure to implement the government's policies and plans over the last decade be carried out. This review should yield the information necessary to decide how to do things differently so that the implementation of all plans are successful. In this final report, the study team has documented a rather large body of actions taken in other countries that have resulted in successful implementation of national plans. The careful review and adoption of some of these actions could assist Malaysia in the development of approaches that will guarantee a higher chance of success.

**Recommendation C: The implementation agency of the new National Green Technology Policy (NGTP) should be changed from its present location in the premises of the Ministry of Energy, Water and Green Technology (KeTTHA) to the Prime Minister's office.**

This move is necessary because of the broad scope of the NGTP. In its present institutional location under the orbit of KeTTHA, the NGTP would lack the clout necessary for the implementation of many of its thrusts and strategies since its actions will entail one line ministry imposing its authority on another. Re-locating the implementation site to the Prime Minister's office will reinforce the pre-eminence of the NGTP vis-à-vis other ministries in all energy-related matters. As part of this move, the study team also recommends that the EPU be made responsible for all sustainability planning activities.

In connection with the three principal recommendations, the study team also recommends that

- the primary audience for the discussion of the actions needed to enhance both STI energy resources and energy-related R&D should be the Prime Minister's Science Advisor. The said Advisor can use this information to formulate a specific and prioritized set of actions for the Prime Minister to consider. The Head of Government can then assign various implementation responsibilities to the relevant ministries with the Science Advisor monitoring progress and periodically reporting back to the Prime Minister with suggestions for changes as and when they are needed.

- the primary audience for the energy-related opportunities that have been identified should be the Minister of Energy, Green Technology and Water (KeTTHA). Most of these opportunities can be driven solely by the ministry. An example would be the setting up and running of "Alternative Energy Sdn. Bhd.", a company that would be responsible for researching and developing a defined package of alternative energy sources.

- the primary audience for the presentation of the roadmap and action plan to assist the government to accelerate sustainable development should be the EPU.

## Effect of Global Conditions on Malaysia's Energy STI Resource and Research Needs

The 2007 publication of the World Energy Council titled, "Deciding the Future: Energy Policy Scenarios to 2050", describes a number of distinct energy-related situations that could develop around the world during the next four decades. The document also lays out the likely consequences associated with each scenario.

The convening of the world body in the Italian capital reached a consensus that any energy outlook must be evaluated in terms of *"The 3A Criteria"*. These are:

- Accessibility – a minimum level of commercial energy services must be accessible to the public at prices that are both affordable and sustainable;

- Availability – there must be long-term continuity of supply as well as quality of service;

- Acceptability – public perception and the environmental impact of all forms of energy utilization must be positive.

The congress also agreed, in principle, upon the following:

- Global energy demand is likely to register a 100% increase by 2050;
- Renewable energy (RE) will make an impact in the 2011-2050 time period but will not dominate any market;
- The changing and complex energy environment over the next 40 years will be managed more successfully through partnerships;
- Demand-side mobilization is absolutely essential to achieving the 3 As;
- Energy intensity is likely to decrease if there is cooperation between the private and public sectors;
- Greenhouse gas (GHG) emissions cannot be controlled without strong government action in each country as well as inter-governmental cooperation;
- More innovation will be needed to reduce the growing imbalance between supply and demand, and governments must play the major role in facilitating this;
- National policies governing the energy sector must be very clear as to intent and less prescriptive as to means;
- For the Asian region, cooperation and integration are essential to increasing the accessibility, availability and acceptability of energy usage; and
- Governments must provide clear and forceful leadership with respect to energy consumption. The word *leadership* in this context means providing vision, direction, guidance, encouragement and resources. Leadership is concerned with the “what” and “why” whereas management is concerned with the “how”.

Energy policy choices need to:

- Ensure an appropriate economic climate to facilitate investment and promote sustainable infrastructure development that will support the growth in energy demand that is anticipated;
- Promote market integration at both regional and inter-regional levels, including a global dialogue on security of energy supply;
- Ensure technology transfer and intellectual property rights in order to develop local energy competencies and promote deployment of better technologies;
- Promote and drive improvements in the efficiency of energy consumption and utilization; and
- Raise the profile of transportation in achieving realistic efficiencies in energy consumption.

Policy actions to deal with any energy future must:

- Articulate strong and consistent long-term principles about energy goals that (a) keep all energy options on the table for individual countries to choose from, and (b) make it is possible to achieve the necessary growth in energy supplies whilst promoting a low-carbon society at the same time;
- Develop regulatory frameworks that ensure attractiveness of markets and competitiveness to industry;
- Promote cooperation between the public and private sectors to identify specific research, development, demonstration, deployment and education (RD3E) projects and funding frameworks;
- Demonstrate strong support for transportation research and facilitate market penetration of new technologies; and
- Support strong and coordinated steps to educate people about energy, from basic principles to critical decisions.

An update to the above world-view from the World Energy Report 2009 makes the following additional points that will impact Malaysia's energy situation.

- Fossil fuels will remain the dominant source of primary energy worldwide over the next 20 years or so, accounting for more than three-quarters of the overall increase in energy use between 2007 and 2030.
- Continuing on today's energy path without any change in government policies would mean rapidly increasing dependence on fossil fuels. This will have alarming consequences on climate change and energy security. Non-OECD countries account for all the projected growth in energy-related carbon dioxide emissions from now to 2030.
- End-use efficiency will be the largest contributor to any abatement in carbon dioxide emissions in 2030, accounting for more than half of the total savings in the (change in business) scenario. Energy-efficiency investments in buildings, industries and transport usually have short pay-back periods and negative net abatement costs. This is because the fuel-cost savings over the lifetime of the capital stock often outweigh the additional capital cost of the efficiency measure, even when future savings are discounted. Decarbonization of the power-generation industry also plays a central role in reducing emissions.
- Measures in the transportation sector to improve fuel economy, expand the use of biofuels and promote the uptake of new vehicle technologies – notably hybrid and electric vehicles – will lead to a big reduction in oil demand.
- New financing mechanisms will be critical to achieving low-carbon growth in energy investment needs. This is because a reduced carbon growth scenario entails USD 10.5 trillion more investment in addition to business as usual. The cost of the additional investment needed to put the world onto a reduced carbon path is at least partly offset by economic, health and energy-security benefits.

- Natural gas will play a key role whatever the policy landscape.  With the assumed resumption of global economic growth from 2010, demand for natural gas worldwide is set to resume its long-term upward trend. However, the pace of at which demand grows will hinge critically on the strength of climate-policy action.

- Gas resources are huge but exploiting them will be challenging. The world's remaining resources of natural gas are easily large enough to cover any conceivable rate of increase in demand through to 2030 and well beyond. However, the cost of developing new resources is set to rise over the long term.

# MAJOR ISSUES AND SHORTCOMINGS

## Current Gaps/Weaknesses in Energy-Sector STI and R&D Development

A selection of the background issues causing STI and research deficiencies in the country is shown below:

- The country does not have an STI culture so programmes to develop STI human capital are limited.
- STI is generally not promoted and hence not perceived as an attractive field for learning and work.
- Historically, open discussion about how to develop STI resources has been limited.
- In order to achieve an optimal pace of development, STI educational opportunities must be filled with the brightest students. Sadly, the current practice of quotas and "set asides" continues to plague the educational system.
- There is a limited performance-based management culture. Hence, there is no recognition for good performance and no penalty for poor results. This induces indifference on the part of STI personnel towards quality work.
- There has been no consistent approach to developing STI resources in the country.
- Development of STI resources has not been extended down to the primary education level.
- Although a number of STI development initiatives have already commenced, the capability to thoroughly implement them has been limited.
- The government clearly needs to have policies in place that allows opportunities for STI students to grow, including ensuring that those exercising control are competent in STI principles.
- Remuneration for top-class STI personnel in Malaysia is very low compared to that in many other countries thus making the field unattractive to students. If at all students enter this field, they typically seek employment outside the country. This problem appears to stem from the mentality of "staying competitive through low wages" which prevailed when the country's economy relied heavily on the manufacturing sector.
- Government bureaucracy does not nurture innovation. Instead, it renders administrative processes excessive to the point that public sector employees have found a haven in a "make work" environment.

- The only way to produce a highly competent human-resource pool is to practise meritocracy in appointments and promotions but this is hamstrung by racial and religious considerations.
- It is abundantly clear that the various policies and plans lack a strong *sustainability* component.
- Reliable mechanisms to monitor how the production and utilization of energy impacts sustainable development have been seriously lacking.
- The political will to correct an obvious incorrect situation is needed.
- Since sustainable development is a long-term concept with a lengthy gestation period and no immediate payoff, there is minimal interest in it.
- Very little attention is being paid to developing the STI resources needed to support the long-term processes that define sustainability.
- Sustainable development is the latest 'fashion' on the development scene so everyone is interested in talking about it in order to look responsible but there is seldom any real action.
- There are many impressive-sounding objectives, goals, thrusts and initiatives but enthusiasm mysteriously diminishes to zero at the implementation stage.
- The country simply does not have an R&D culture.
- There is limited coordination amongst the various ministries and agencies, the consequence of which has been minimal co-operation and sharing of information.
- Historically, science and technology have not featured prominently in the economic and national development agenda. For example, GLCs are viewed only as sources of revenue, not of R&D.
- The faithful implementation of sustainable development plans is at risk from the prevailing bureaucratically-driven mode which often results in unnecessary and unproductive effort.

# VARIOUS INTERNATIONAL STUDIES

## The World Bank Forum, Washington D.C., 2007

STI capacity building involves the capacity to acquire and use existing knowledge, and to produce and use new knowledge. It also involves building capacity in four distinct dimensions:

- government policy making;
- labor force skills and training;
- enterprise innovation; and
- education: academic, vocational, training and research institutions.

Malaysia needs to use this framework to make sure all dimensions are properly included in its STI capacity-building activities.

Successful latecomer strategies for catching up in STI development include:

- The processes of technology diffusion, linkage, leverage and learning; and
- Identifying and driving the array of skills and capabilities that individual enterprises must develop.

Strategic operational, organizational and implementation issues that must be addressed in order to successfully increase STI capacity include:

- Sequencing and prioritizing regarding STI capacities to be built;
- Selection of skill sets to be developed;
- Sequencing and prioritizing of technology development;
- Selection of development path for STI institutions and programmes;
- How to adapt STI programmes from advanced economies; and
- What cross-sectoral efforts should be pursued.

Tactical STI capacity-building issues that must be addressed in order to successfully increase STI capacity include:

- Identifying the key developmental challenges in specific sectors and industries;
- Determining whether individual businesses have the ability to identify new potentially useful technologies and adopt them for use in the business;
- Deciding whether the country's limited STI capacity should focus on serving the global market or the local market;

- Identifying if there are negative impacts from implicit STI policies (e.g. tax policies, import policies, etc) that will offset the expected benefits of any STI capacity-building initiatives; and

- Determining how STI capacity building can help to reverse any brain drain occurring in the country.

## Country-Specific Ideas

### China

The paper "Open Access to Scientific Data: Promoting Science and Technology Innovation" outlines the approach China has used to ensure that all STI capacity-building activities, including tertiary and advanced-degree education, share knowledge and cooperate in their work. Malaysia should follow China's example in this area.

While the scale of the effort in China is much larger than what would be the case in Malaysia, the concept of data/information sharing and a common data/information repository among universities and institutes with respect to R&D projects and results is essential for the country to be able to multiply the results of its limited R&D efforts.

### Finland

Malaysia should investigate and emulate the Finnish approach to R&D funding as a means of achieving centralized financial backing of energy-related opportunities.

SITRA is a public foundation that reports directly to the Finnish Parliament. The independent body, chaired by the former Prime Minister, is tasked with the responsibility of promoting the economic growth and future success of Finland through international cooperation and competitiveness. The foundation's operations can be divided into two parts, namely, (1) research, education & collaboration, and (2) venture-capital funding. In the latter of these two operations, SITRA was clearly one of the country's pioneers.

The methods employed by SITRA include research, strategy-building processes, innovative experiments, business development and investment in internationalization. While the foundation's initial emphasis was research, it focuses today on its new venture-capital investments. The aim of any investment in the early stages is to create and develop a competitive and profitable business. The overall objectives are to make Finland a global leader in the high-technology marketplace and to improve the national innovation system with SITRA as a 'driving actor'.

Thus, the Finnish model for applying technology and innovation-oriented funding to the processes of national development provides a good example for Malaysia to emulate, at least in some measure.

## Ireland

In the document titled "Strategy for Science, Technology and Innovation", Ireland took the assumption that manufacturing growth is expected to remain a key driver of economic development. In this manner, it links its capacity-building activities directly to economic goals. Since Malaysia is similar to Ireland in this (manufacturing) respect, a dialogue with Ireland on how the latter intends to build its STI capabilities whilst maintaining its manufacturing base would certainly be useful.

Some of the ideas developed by the Irish in the document cited are:

- Specific actions will be needed to move R&D results from research centres to commercialization;
- Additional steps will also be necessary to address intellectual property (IP) or commercialization considerations in research institutes and universities;
- The government should support resource-intensive and cross-institution projects; and
- A single-point responsibility for coordination and development of STI capacity will be needed.

What Malaysia could consider imitating are the structures and approaches the Irish have used to support the implementation of strategies, as listed below.

- Use a portfolio approach in selecting R&D priorities;
- Develop a technology-assessment process in which the assessment principles include (a) potential for quality research and critical mass in the industry area, (b) potential to create an international uniqueness for the country in certain research areas, and (c) relevance to the country's future industrial, economic and social development;
- Decide what infrastructure is needed at which universities to support particular research programmes;
- A central monitoring and coordinating agency will oversee the efforts to enhance STI capacity and R&D;
- Sectoral research needs will be prioritized (in this case, energy-related research); prioritized research requirements will directly link university research, sectoral research and enterprise research so that all research investment can translate into economic benefit; and
- There will be clear and transparent reviews, evaluations, targets and indicators used to communicate progress to the oversight bodies and to the public.

## Japan

The document titled “Energy Policies of IEA Countries, Japan 2008 Review” provides a number of valuable ideas on what the Malaysian Sustainable Development plan should look like in its end state.

Such useful ideas are as follows.

- Policies and plans must set specific numerical targets to be achieved by specific dates.
- Before a policy is adopted, it should be subjected to a cost-benefit review i.e. an ex-ante evaluation. By comparing the value of a policy to its cost of implementation, the most cost-effective way of achieving results can be identified.
- After the policy is adopted, there should be periodic ex-post evaluations to confirm that it is indeed delivering on the expected benefits. If, however, this is not the case, then (a) adjustments must be made, and (b) the weaknesses in the policy leading to below-expectation results must be identified. This is essential so that the same mistakes will not be repeated in the formulation of future policies.
- Malaysia should organize genuine “lawatan sambil belajar” programmes to Japan so that trainees can benefit from Japanese expertise in raising EE standards. Malaysia should also consider inviting Japanese experts to our shores to assist in implementing advanced emission-reduction projects.

R&D programmes currently supported by the Japanese government include (1) renewable-energy technology, (2) energy-conservation technology, (3) fossil-fuel technology, (4) nuclear technology (e.g. projects to improve the next generation of nuclear reactor); and (5) electric-power technology (e.g. projects related to power system improvements). The government also gradually reduces its support as R&D progresses from the basic research stage to the commercialization stage.

## The United States of America

The report on “America’s Energy Future” illustrates what can be attained with sufficient time and resources. While the report has identified many available options to secure an energy future, this could happen in Malaysia if the recommendations in the report are acted upon. In order to drive effective action, there is an immediate need to coordinate all research, development, demonstration, deployment, and education (RD3E) activities so that they complement each other and operate *as part of an overarching plan*.

Finally, the report clearly states that market forces, rather than central planning, is a more effective way to achieve progress. The concept here is to allow the market to operate to its fullest potential but within government-established parameters. For example, the government can establish fuel-consumption standards for vehicles and manufacturers are then responsible for meeting the standards in the most cost-effective way. Similarly, standards for appliances can be established and the industry again is free to meet the standards in the most cost-effective way. This approach properly recognizes two roles: (1) the government’s in guiding the production of public goods, and (2) the private sector's in finding the least-cost method to achieve the production of these goods.

In the document titled "Building a Sustainable Energy Future: U.S. Actions for an Effective Energy Economy Transformation", the US government clearly demonstrates its intention to lead a nationally-coordinated RD3E strategy to transform the national energy system into a sustainable-energy economy that is far less carbon intensive.

The sub-strategies to realise the over-arching strategy include:

- Adopting stable policies that facilitate discovery, development, deployment, and commercialization of sustainable energy technologies;
- Establishing a federal leadership body to coordinate all activities related to sustainable energy;
- Adopting sustainable energy measures and analyses throughout the Federal Government;
- Organizing energy-related RD3E activities across the USA to link scientific discoveries with technological innovation;
- Increasing federal investment in sustainable energy R&D;
- Encouraging investment in research aimed at commercialization of sustainable-energy technologies;
- Bolstering science-and-technology education related to sustainable energy at all levels;
- Bolstering the workforce training in sustainable energy-related fields;
- Engaging in global cooperation for sustainable energy strategies;
- Reducing barriers to cross-national collaboration in sustainable energy-related research; and
- Informing consumers and motivating the public to actively seek out, invest in, and implement energy-saving practices and technologies.

Most or all of the above ideas are worth careful consideration.

Malaysia is currently addressing a number of ideas identified in another study titled "Building a Science, Technology, Engineering and Math Agenda". Useful ideas from this study include:

- Incorporating STEM (science, technology, engineering and mathematics) education at the primary and secondary levels so as to create a coherent STEM education process;
- Aligning STEM education standards and assessments towards post-secondary and workforce expectations;

- Identifying various ways, including an appropriate reward structure, to improve the quality of teaching; and

- Identifying new teaching approaches and models that focus on rigour and relevance to ensure that all students are STEM literate.

The ability to innovate and compete directly on a global level will depend very much on the adequacy of secondary education to breed students that can take advantage of STEM literacy. To succeed in the knowledge-based work environment, students need to be proficient in all four areas of STEM, namely:

- Scientific literacy – the ability to apply scientific knowledge in decision-making in the natural world.

- Technological literacy – the ability to understand, use, manage and assess various technologies.

- Engineering literacy – the ability to understand how technologies are developed.

- Mathematical literacy – the ability to analyze, interpret, reason and communicate solutions to mathematical problems in a variety of situations.

The mark of a "STEM classroom" is one that emphasizes critical thinking and application of STEM knowledge in everyday life. However, a student's STEM-competency can be achieved only if teachers are STEM-competent in their respective areas.

The two key messages here are:

- There can be no progress in STEM capacity in the country without a fully STEM-competent and highly-motivated teaching cadre.

- Effective STEM education at the primary and secondary levels would require a massive change in the education process from the current "examination-oriented" structure to a structure that emphasizes critical thinking and application of STEM knowledge.

Clearly, the STEM concept is at the heart of STI capacity building taking place at the most fundamental levels of the education system. Without the introduction of STI education through STEM at the primary and secondary school levels, there is very little chance to achieve STI capacity development at the tertiary level.

**Recommendation: The study team suggests that STI education be implemented at the primary and secondary education levels within the next 24 months.**

Malaysia should explore the possibility of securing complete STI-course curricula from leading universities which provide them free on the Internet. This information can be used to develop programmes for specific areas of STI-capacity development. For example, most of the course material from the Massachusetts Institute of Technology (MIT) is available from the Internet.

# DEVELOPING STI RESOURCES & CRAFTING SD PLANNING PROCESSES

## Enabling Conditions

The international-experience review has identified a number of conditions that must be present in order to successfully develop STI resources (both infrastructure and human capital) and a sustainable-development (SD) plan. There must be at least the following:

- Strong and effective leadership in all aspects of the energy sector.
- Adoption and consistent enforcement of standards related to energy efficiency and SD.
- A mindset oriented to keeping all options open for consideration.
- A clear and effective governance structure for the processes of STI development and SD planning.
- Availability of sufficient financial resources (e.g. funding levels that meet the needs, properly co-ordinated funding to focus on prioritized STI development needs and SD activities, continuous funding over time).
- Removal of the various barriers to SD.

### Strong and Effective Leadership

Specific actions to take in order to exercise *strong* leadership include:

- Reducing energy subsidies over a 5-10 year period so that natural gas, petrol and electricity prices are all at commercial levels. The impact of weaning the public off subsidies will be a significant reduction in the liberal use of energy. From the government's standpoint, this will reduce overall national expenditure in the energy sector.
- Adopting new standards and uniformly enforcing all standards, both new and existing.
- Review existing standards to identify those that are irrelevant, inappropriate or biased with a view to removing the aforementioned barriers to development.
- Promoting the view that Malaysia can be a niche player in developing a skill-and-experience base that would support its efforts to become a leading energy player in selected areas (e.g. in solar energy and biomass).
- Assigning specific areas such as (1) energy-opportunity research, (2)

development, and (3) commercialization responsibilities to specific universities, institutes and GLCs. In this way, there will be clearly-identified, accountable parties for achieving realization in definite energy-related areas.

- Commissioning PETRONAS University to acquire or develop an energy-specific input-output model for Malaysia so that the government will have a quantitative tool that can be used to explore the impact of prices on economic activity.

## Availability of Funding

Malaysia has already established a number of different funding mechanisms to support STI development and implementation of energy-related technologies. Most of these mechanisms appear to be of a grant nature in addition to some tax schemes. However, there does not appear to be a coordinated effort to ensure that the projects being funded truly operate in support of one another to maximize the value derived from money spent.

The government should consider establishing innovative funding mechanisms to accelerate adoption and commercialization of new energy-related technologies as new businesses. Some suggestions of such mechanisms are as follows.

### *(1) Grant programmes*

Government grant programmes to fund R&D could include a provision that if the R&D leads to commercial products or services, those benefiting from such commercialization would be required to repay a portion of the R&D cost initially covered by the grant (e.g. 50% or 75% of the grant over a defined time period). Companies benefiting could be granted a monopoly during the period of repayment.

### *(2) Revolving fund*

A revolving fund would provide financial assistance to help defray the initial cost of adopting new and improved technology. Funding provided would be recovered over a defined period of time from the extra returns the investor makes as a result of reduced operating costs and energy savings.

Existing government funding must be centralized into this revolving fund with its own independent board of trustees. An independent board will ensure that the allocation of funds will be based on technical competence and priority levels of energy-related opportunities. The board would be responsible for allocating funds to universities, institutes and GLC R&D efforts. Thus, the board would be expected to evaluate each opportunity and select those that (a) meet the right time-frame, (b) are most likely to attract other funding to assist with further development, and (c) provide the greatest contribution to the country's energy-sector development.

A certain float (say, 10-15% of the revolving fund) should be reserved so that the board could consider new applications. Repatriation to the fund is needed to complete the cycle. So, any funding of opportunities should carry a requirement that the recipient be obligated to repay the fund through a pre-determined share of any savings realized.

In order to achieve the independence needed in the administration of the fund, the study team suggests that ASM be responsible for assembling a competent and independent board.

### *(3) Green energy tax*

To increase the funding available for these energy-related opportunities, a “green energy” tax dedicated to the “Green Technology Fund” should be imposed. This tax should incorporate the “polluters must pay” concept. The main purpose of such a tax would be to show potential funding organizations abroad that the country is serious about sustainable-development efforts. This will enhance the chances of receiving additional funding. This approach has been used successfully by South Africa.

### *(4) Tax schemes*

Since Malaysia already has taxation laws in which accelerated depreciation on new or additional investments would be allowed, it should use this structure in relation to new energy-related technologies. Other forms of tax relief can also be developed.

# VARIOUS NATIONAL PLANS

## The Knowledge-Based Economic Master Plan (2002)

A document prepared by EPU in 2002 identified the serious shortcomings in STI resource availability and development capability at that time. A set of recommendations intended to fix the shortcomings were also proposed.

The study team believes that this EPU document should be required reading for MOSTI and MOHE **before** they complete preparation of their plans to expand and improve the STI resources of the country because:

- First, the EPU Plan identifies the main shortcomings that were present in the STI resource base in 2002 and are still present for the most part today, 7 years later.
- Second, the EPU Plan recommendations are very similar to the plans that are being prepared by MOSTI and MOHE to address the same issues, so the EPU Plan can provide a "reference check" for areas to be covered.
- Third, and most important, since the EPU Plan recommendations have only been minimally implemented, it is essential that MOSTI and MOHE review the history of what happened between 2002 and 2009 to identify the reasons for failure to implement their plans so that the plans now being prepared can be designed to effectively deal with the same elements, factors and forces that led to the failure of the EPU Plan. In this way, we can prevent failure of the plans that are currently being prepared.

If this learning exercise is not undertaken, almost certainly the current plans will experience the failure over the next 10 years that the EPU Plan experienced over the last 10 years.

## The Outline Perspective Plan 3 (OPP 3)

The OPP 3 paints much the same picture as the previous plans. It has identified important things that need to be done in the current decade (2000-2010), for example, building human capital, increasing productivity, increasing capacity for knowledge absorption and utilization in order to achieve sustainable economic development based on STI resources. However, as was the case with the EPU Master Plan, progress has been minimal. Specific areas identified in the OPP 3 in need of attention during the first decade of this century include:

- Strengthen human capital development to produce a competent, productive and knowledgeable workforce;
- Emphasize product innovation and R&D;
- Build an indigenous capability to develop advanced technologies and new products and services;
- Further develop the venture-capital industry to be a source of equity capital for

knowledge-based start-up companies;

- Increase productivity by upgrading skills, adopting improved management practices and upgrading R&D and the STI resource base; and
- Develop the entrepreneurial and technopreneurial capacity in the country.

Clearly, the OPP 4 will need to review what has happened over the last 10 years so that it can be designed to avoid the problems that limited the success of the OPP 3.

The study team has, in the course of its work, seen that the situation at the end of the decade has not changed much from whatever is described in the OPP 3, especially in the area of venture capital, STI and the energy sector.

### The National Higher Education Plan (2007-2010)

A review of the National Higher Education Plan revealed additional weaknesses.

- The plan does not appear to have achieved its targets. This is substantiated by the continued shortage of technically-trained graduates, the large number of university graduates unable to find jobs, and the need for many university graduates to undergo vocational training in order to acquire employable skills.
- Not a single one of the strategies specifically addresses the urgent need to deepen and broaden the STI resource base of the country.

A number of initiatives in the plan were designed to skew the tertiary education system to play a leading role in the broadening and deepening of the STI resource base in the country.

Some of these initiatives were:

- to grant universities a greater level of autonomy and accountability so that they can become more dynamic institutions of learning;
- to establish the right process for selecting university faculty members;
- to establish a remuneration system based on merit;
- to strengthen the performance-review process for educators;
- to require top-tier universities to develop excellent R&D facilities that result in commercialization;
- to increase funding for STI courses and for the establishment of a collaborative national innovation system; and
- to create 'apex' universities that can match the stature of the best learning institutions in developed countries.

One bold suggestion worth considering is to transfer control of all research grants of such institutions to MOSTI with MOHE retaining its role as the overseer of all universities in the country. With direct control over research grants, MOSTI would be in a strategic position to facilitate R&D efforts that are most relevant to STI development while MOHE continues to ensure that stipulated academic and performance standards are met.

There appears to be an even more serious problem in the making as a consequence of the decision on the teaching medium. The country is certain to face an acute shortage of primary and secondary teachers qualified to teach Science and Mathematics. Clearly, for the next 5 to 10 years, there will be a struggle to develop this particular human resource and the number of competent students with basic scientific and mathematical skills entering tertiary education will be minimal. A longer-term consequence of this will be a reduced volume of quality STI graduates in the next 10-15 years.

**Recommendation: The study team recommends that the teaching of science and mathematics should be continued in English.**

MOSTI and the MOHE should also consider pairing research institutions with technical universities. The curricula should be altered so that it becomes mandatory for science and engineering students to pursue specific courses in each other's disciplines. This move would (1) holistically improve the ability of both scientists and engineers to commercialize R&D results, (2) create more opportunities for academic development through work on practical, real-life projects, and (3) provide competent low-cost research staff for institutes.

## MOSTI STI Strategic and Action Plan (2010-2020)

This MOSTI Plan is of very high quality and contains all the elements needed to significantly enhance the STI resource base of the country. In order for MOSTI to deliver on its promise entailed by the plan, it will need to be the lead organization for STI development. MOSTI will thus have to coordinate very closely with KeTTHA in order to identify the most immediate STI-priority needs to be addressed.

Finally, the study team reiterates the need to make changes in the university-education system so that MOSTI is given "single-point responsibility" for all basic and applied research and STI capacity building in agencies and RIs. As indicated earlier, MOSTI must also review the earlier plans that have not produced the deliverables that were promised. With this corrective action, MOSTI can be more assured of success in the implementation of its brand new plan.

## The National Energy Efficiency Master Plan

This plan, in conjunction with MOSTI's 10-year plan, describes a number of strategies needed for Malaysia to succeed in promoting energy efficiency (EE). The study team believes effective action is possible only if there is a coordinated process that is the responsibility of a single organization. The current situation in which at least four line ministries are responsible for various parts of all plans has resulted in significant duplication of effort, insufficient funding, competing objectives and very little progress being made in achieving EE over the last 10 years.

The work on the National EE Master Plan to date found that:

- There is vast potential to save energy through its rational use provided that the long-standing barriers and weaknesses, itemised below, are addressed. If not, these will continue to perpetually hamper the advancement of the EE policies and strategies.
- The realization of this potential to save energy requires:
  - ➢ A new legislative act to compel designated users to meet a mandatory requirement of adopting EE practices;
  - ➢ The creation of a central data and information repository for all gathered findings;
  - ➢ A standardized Building Energy Index (BEI) computation to ensure uniformity of measurement so that EE in the building sector can be effectively analyzed; and
  - ➢ A mechanism to assist users wanting to invest in energy saving measures.
- Existing institutions and agencies involved in EE activities are fragmented in approach and lack a common direction. There is no lack of human resources put in place by the government. However, due to the duplicating effort by various authorities and parties, the result has been far from satisfactory.
- It is extremely important that the administrative mechanisms for EE be empowered by a single ministry or a new agency to avoid the current bureaucratic problem involving four line ministries that has been the bane of EE success thus far.
- With respect to this issue, the study team recommends that:
  - ➢ Trained personnel to plan, manage, monitor, support and evaluate the EE programs against the EE objectives and targets be put in place;
  - ➢ The lack of a legislative framework, which has been identified as the major barrier to EE progress in Malaysia, be addressed as a top priority; and
  - ➢ securing available funding and human resources be quickly implemented. An option to secure this funding is for the government to establish a "Clean-Energy Investment Fund" which could be sourced from a small percentage of the electricity tariff adjustment, a small percentage of the next gas-price adjustment, or some of the existing petroleum CESS funds for national EE and RE programs.
- The single main obstacle to EE progress has been and remains the subsidized energy tariff. It is thus recommended that the process of gradually reducing gas and electric subsidies be commenced with immediate effect.
- There are five common factors that dictate the success of energy efficiency and conservation (EE&C) policies:
  - ➢ Enactment of a dedicated EE&C legislation;

- Extensive labeling of appliances and equipment;
- One-stop agency for EE&C implementation;
- A solid financial support system and mechanism; and
- A "champion" to drive EE&C strategies.

**Recommendation: The study team recommends that all the above actions must be undertaken within the RMK10 period.**

## The National Renewable Energy Policy and Action Plan

The National Renewable Energy Policy and Action Plan makes the point that Malaysia's efforts in the RE sector have not been successful. The report identifies the reasons for failure and the changes that have to be made for RE to become an important contributor to the energy-supply side in the immediate and longer-term.

The proposed forward-looking RE Policy to address the past failures comprises:

(1) A Policy Vision, quoted below

> "Enhancing the utilization of indigenous renewable energy resources to contribute towards national electricity-supply security and sustainable socio-economic development."

(2) Five Policy Objectives

- To increase RE contribution in the national power generation mix;
- To facilitate the growth of the RE industry;
- To ensure reasonable RE generation costs;
- To conserve the environment for future generations; and
- To enhance awareness of the role and importance of RE.

(3) A Policy Mission comprising five strategic thrusts, as follows:

Thrust 1: Introduce the appropriate regulatory framework.

Thrust 2: Introduce a supportive stimulus package for RE businesses.

Thrust 3: Intensify human-capital development.

Thrust 4: Enhance RE research and development.

Thrust 5: Design and implement an RE advocacy programme.

Thrust 1 is the foundation for the five policy objectives whilst Thrusts 2, 3 and 4 provide the stimulus for businesses to enter this market, the necessary knowledge workers and the competitive advantage.

Since the RE Policy is a forward-looking one with new approaches, it is important for its success that buy-in by relevant stakeholders and society at large is secured. Hence the advocacy programme in Thrust 5.

**Recommendation: The study team recommends that the implementation of the 5 thrusts be completed within the RMK10 period.**

# NEW ENERGY OPPORTUNITIES

This Mega Study has identified a number of sources of future growth opportunities in the energy sector that can be considered by the government. An appropriate agency of the government should examine these opportunities and determine which of them can be realized in the immediate term (within 5 years) and which in the longer term (beyond 10 years). The energy-related opportunities identified by the study team are of three kinds: (1) new energy-related business opportunities, (2) opportunities for improving the efficiency of energy use in the country, and (3) opportunities for enhancing STI-resource capabilities and energy-related R&D. The recommended opportunities identified in this study are summarized below.

## (1) New Energy-Related Business Opportunities

### Accelerate the Development of Solar Thermal Cooling (STC)

- Set a target for penetration of solar thermal cooling on the roofs of existing industrial and low-rise commercial buildings and a target for utilizing new buildings for the next 5 years.
- Fund well-defined R&D activities to refine and further develop STC technology and make it available to SMEs currently producing these units so they can improve the quality of their products and thus more easily penetrate the regional market.
- Target significant improvements in performance and cost of units over the next 5 years.

The key advantage of this opportunity is that cooling is direct, thus there is no need to convert solar energy to electricity to be used in cooling equipment.

### Support Additional R&D for Small Cogeneration Cooling Units

Small cogeneration cooling units are particularly suited for use in the non-industrial sectors. The unit is extremely exergy-efficient and uses LNG/LPG for fuel. There is a very large market for such products domestically and in the region. Because of the large market potential for the product, the target for market availability should be 5 years or less to allow for the needed R&D.

### Substitute Synthetic Refrigerants with Hydrocarbon (HC) Refrigerants

The major benefits of pursuing this conversion in Malaysia include:

- significant reduction in foreign exchange expenditures (substituting local production for international purchases);

- reduction in carbon emissions because HC refrigerants use less energy (both electricity and fuel in motor vehicles) to achieve the same cooling results;
- lower cost of cooling because HC refrigerants are cheaper; and
- the creation of a new industry that companies in Malaysia can expand into.

The estimated potential payoffs from pursuing this opportunity include:

- Forex savings from using HC refrigerants to replace the imported refrigerants currently in use could be as much as RM 200 million per year;
- Replacement of current refrigerants with HC in automobile air-conditioners represents a potential fuel savings of 60 million litres per year;
- Replacement of current refrigerants with HC in resdential, commercial and industrial uses represents potential electricity savings of 368 GWh per year, which is currently 0.5% of total electricity consumption.

PETRONAS should be directed to produce the raw materials and be compensated using the savings achieved should a loss arise.

### Develop Malaysia's Solar PV Potential into a Major Industry

Since Malaysia already has a position in the PV manufacturing industry, this opportunity focuses on expanding this position to become a major industry penetrating international markets. The study team believes that this transformation can occur over the next 10 years.

Looking first at the benefits to be realized from developing the PV industry, it has been estimated that such a development would consist of:

- The establishment of a new technology sector with high-growth potential possibly providing 100,000 jobs cumulatively by year 2020;
- Making Malaysia one of the world's top five PV-equipment-manufacturing countries with a possible global manufacturing share of 10%. This would generate a cumulative revenue of more than RM560 billion by 2020, of which 50-70% of the value would go directly to the local industry; and
- Providing direct benefits to local industries that will be worth an estimated RM280 to RM400 billion depending on value chain of the products.

It is estimated that the cumulative revenue from the PV industry could contribute up to 4% of the National GDP by 2020.

In order for Malaysia to capture a 10% share in the global PV manufacturing industry, an estimated RM250 billion would be needed from 2010 to 2020. This amount would also stimulate the local economy as most of the money would be spent locally.

This cumulative cost includes direct and indirect investments (for example infrastructure, capital expenditure, R&D, industrial programmes, etc.) and should be shared amongst the

MNCs (about RM100 billion), the industry (about RM73 billion), the government (about RM57 billion) and other related stakeholders (about RM22 billion). Nevertheless, the cumulative direct benefits to the local industry generated by 2020 would outweigh the costs by 130% to 160%, even without considering the impact of the business revenues from the PV industry.

The study team recommends that the government establish a National PV Industry Development Programme to address the following issues.

### *Industry Enhancement*

- Create coordination between various government agencies for PV-industry development.
- Intensify human capital development, for example, focusing on industry missions, sponsored exchange programmes such as apprenticeships, and international training.
- Facilitate partnerships between MNCs and the local industry.
- Upgrade targeted local industries to PV business (for example wafer fabrication, electronics) as this presents lower costs, lower entry levels and faster implementation.
- Introduce industry quality and award schemes as well as demonstration programmes.

### *Infrastructure*

- Introduce business facilitation packages (e.g. soft loan schemes, focus grants) for local industry to enter and expand in PV business.
- Promote IP acquisition and FDIs with focus on direct benefit for the local industry (thus triggering domestic direct investments).
- Identify government or GLC investments in new promising PV technologies and catalyze the development, incubation and creation of fast spin-offs.
- Establish internationally recognized test facilities and a PV R&D center to support the R&D activities that will be required.

### *Research, Development and Innovation*

- Design and implement a national PV R&D roadmap (with focus on technology innovation and cost reduction).
- Establish a review and advisory committee (with local and international experts).

- Increase the R&D budget for PV technology and processes with constant monitoring and feedback from the industry.
- Enhance industry collaboration with academics.
- Exploit the brain gain programme (with a special focus on PV technology) and foster technopreneur growth.

### *Conducive Market Environment*

- Introduce a Renewable Energy (RE) Law which includes a Feed-in Tariff (FiT) mechanism with specific National RE targets.
- Implement a cost-sharing mechanism via the RE Law (by creating a RE Fund) to offset the incremental cost of the FiT.
- Implement regulatory conditions for grid-interconnection via the RE Law, for example, access to the national grid.
- Promote public awareness and implement advocacy programmes.
- Install PV systems in government buildings and promote Green Building Index (GBI) compliance.
- Design a long-term national energy plan based on RE and solar energy.

In addition to addressing the above issues, the programme will need to establish a dedicated team in a central agency with the right competencies and strong expertise in all aspects of the PV industry. This agency should be empowered to undertake coordination activities in a transparent and unbureaucratic manner and be accountable to the highest levels of the government on a periodic basis.

## (2) Improving the Efficiency of Energy Use in the Country

### Enforcing Minimum Energy Standards for New Building Construction

This represents the easiest and most sustainable measure that can be taken to reduce energy use in the long term. This approach should then be followed by reduction of energy use when retrofitting existing buildings. Minimum-consumption energy standards can be realized if the government adopts, promotes and enforces the industry-driven Green Building Index (GBI) that addresses all aspects of energy efficiency in buildings.

Compliance with the GBI requirements could potentially reduce energy use in buildings from 20% to 60%.

Imposing standards should start with new buildings. (Note that compliance for new buildings could increase building cost by 1-3%.) Retrofitting existing buildings should be mandated initially for all buildings that are being renovated and subsequently for all buildings on a retrofit basis. A mandate is required to achieve national savings in energy usage.

The standard levels should be set based on a study identifying the range of savings for a range of investments.

### Set Increasing Fuel Economy Standards

Within one year, perform the necessary analyses to determine the viability of a proposal that requires vehicles to consume less fuel per kilometre followed by implementation of the proposal. A quick analysis using reasonable assumptions indicates that if a standard requiring a 15% improvement in fuel consumption were imposed now, the annual fuel savings by 2025 could be at least 1.6 billion litres of fuel.

### Proposal to Rely Entirely On Diesel Engines in All Future Road Vehicles

Undertake a one-year automotive-engineering study to determine if this proposal would achieve significant fuel savings and reductions in emissions. The study should ascertain if these and other associated benefits would outweigh the loss in "freedom of choice" for the consumer.

This study must consider the impact of the proposal on the development of bio-diesel production in the country, including the alternative sources that are currently operating. In particular, the study must examine the present preference for using palm olefin rather than methyl ester for blending purposes. The study must also look at the issue of how to prevent petrol kiosks from diluting or adulterating diesel fuel in pursuit of more profit. If the benefits outweigh the costs, the proposal should be implemented within 5 years.

### (3) Enhancing STI Resource Capabilities and Energy-Related R&D

Consolidate all research currently underway regarding "clean coal" potential into a single project with a 3-5 year life. This project will identify technical approaches that Malaysia can use within the country (e.g. the coal fields in Sabah and Sarawak) and in neighboring countries (e.g. Indonesia) to reduce the carbon dioxide emissions from coal combustion. Technical approaches currently under consideration include:

- Extensive work in CCS
- IGCC potential
- Coal-to-liquids potential
- Underground coal-gasification potential
- Enhanced fluidized-bed-combustion technology

The study should focus on the work that has already been done with respect to (1) carbon capture by algae in which the algae are subsequently processed into biofuel, and (2) carbon capture by treating the flue gasses with salt water which converts the carbon dioxide into calcium carbonate that can then be used to make concrete aggregate. Both of these new technologies for carbon sequestration are at the stage of testing for operation on a commercial scale. It is hoped that Malaysia could become one of the international test locations offering its services for companies wishing to make an entry into this new technology.

Establish a research project of 12-15 months duration to confirm the assertion that there is a 50,000 MW potential of ocean thermal energy in the Sabah trench. The project would have to identify exactly what STI resources are needed as well as estimate the funding required to convert this potential into actual electricity generation.

## Establishment of a Special-Purpose GLC

Since the country has to be looking at the development of alternative multi-energy sources, a reasonable question to be asked is, "What is the most cost-effective way for Malaysia to do this?" The study team is aware that the country has had success with GLCs being given responsibility for developing specific areas. The idea here is to establish a new company to be responsible for researching and developing a defined package of alternative energy sources. The initial list of 'candidates' could include:

- Solar photovoltaic energy;
- Large hydroelectric power;
- Geothermal energy (in Sabah and in neighbouring countries);
- Coal-bed methane;
- Underground coal gasification;
- Bio-diesel (from sources other than palm oil); and
- Biomass.

**Recommendation: The recommendation of the study team is the setting up of this company as a wholly-owned subsidiary of PETRONAS. Such a recommendation is being made for several reasons.**

- ***PETRONAS has a strong STEI (science, technology, engineering and innovation) resource base.***
- ***PETRONAS could commission the relevant R&D to be carried out at its university.***
- ***PETRONAS already has a unit that is analyzing alternative energy resources.***
- ***PETRONAS has the resources necessary to provide both the initial funding as well as the administrative structure to run this company.***
- ***PETRONAS has a huge bank of experience in dealing with suppliers, vendors, developers and investors.***
- ***PETRONAS has a track record as a very successful MNC.***

This subsidiary would have its own charter, management and staff. The subsidiary's objectives and focus would be jointly defined by the government and PETRONAS. Oversight, the monitoring of progress and the 'push' towards commercialization would be the responsibility of PETRONAS.

The study team believes that this approach would be a much more cost-effective way of researching and developing alternative energy sources than merely leaving this to the market. Malaysia is a small country with limited resources that need not be wasted by funding a variety of alternative proposals at the same time. The subsidiary company would have the competence to screen multiple proposals, identify those that look promising, then establish an appropriate commercial relationship with the chosen parties that will ensure success for each energy project.

Establish a research project of 12-15 months duration to determine what is required to convert the existing motorcycle fleet in the country from petrol to electric power, similar to what has been done in China. The benefits from this change would be reduced petrol consumption, reduced pollution and the increased use of electricity to offset the current surplus in supply. There are both technical and practical considerations here, the practical one being the need for higher speeds on motorways for intercity travel.

Establish a research project of one-year duration to study projected energy consumption patterns in 5-year increments for the next 15 years to determine usage categories. Some of the questions that could be asked are:

- What is the source of energy used by each category?
- Is the source for a particular application the best one?
- What would be the reasonable level of consumption if the right fuel were used?
- What would be the energy-use efficiency gain from using the right fuel?

The answers aggregated from the project would facilitate better planning on the energy-supply side.

Establish a research project of 24 months duration to assess the potential for Malaysia to develop an "energy-crop farming" sector. Energy crops are plants or trees grown specifically to be used in energy productio e.g. switch grass, jatropha, etc. The next generation of biofuels is expected to be made from cellulosic biomass – residues from agricultural and forest practices, crops grown only for conversion to fuels, and municipal solid waste – which offer substantial reductions in GHG emissions relative to petroleum-based fuels.

To achieve a meaningful and sustainable supply of cellulosic biomass, special incentives would have to be provided to farmers and developers. They should be encouraged to use a 'systems approach' for growing and collecting the biomass and converting it to biofuel. This is an approach that addresses soil, water, air quality, CCS, wildlife habitat and rural development issues in a comprehensive manner. Additional questions the study would need to answer include:

- Is there sufficient land suitable for this type of farming?
- Could this land support food crops?

- Which energy crop would be most suitable?
- What are the economics of such farming?

# A HIGH-LEVEL FRAMEWORK

During the course of the study, the team became aware of a number of parallel studies related to sustainable development and enhancement of the country's STI resource base that were being undertaken by other parties. A careful review of each of the above-mentioned plans and policies revealed that there were virtually no cross-references between all these nonetheless laudable attempts. It appears that each plan or policy was constructed to deal only with those areas that were of concern to the formulating party. None of these studies was prepared within a framework that had an overarching objective and a single set of goals that the government wanted to achieve. Consequently, the current situation is one in which there are numerous plans and policies for development in a number of key areas but none of these is comprehensive. At times, related areas of vital significance are not sufficiently addressed. A considerable degree of duplicity and overlapping is evident everywhere.

## The Framework Concept

In order to streamline the efforts of all the parties concerned and maximize the gains that can be derived from the collective knowledge, wisdom and experience of those involved, the study team is strongly recommending that the government establish a formal framework within which all the planning for the country's energy future will have to take place. This will require a paradigm shift on the part of the top leadership and a strong political will to tread a path that has never before been trodden.

The establishing of such a framework will bring a set of clear advantages. Planning in each area will continue to be done by the organization best qualified to do so but the formulation of the plan or policy will have to stay within the bounds of stringent overarching objectives identified by the government. Furthermore, the planning will have to be structured so that a mere glance will reveal if the goals and objectives are being met. The government will also be able to identify which ministries are meeting the sustainable development goals they are responsible for and which are not. In this way, corrective action can be taken to improve the performance of the faltering ministry. During the preparation of the Annual Budget, the government will be able to review each ministry-specific budget proposal in the context of the proposed plans and policies, then skew the allocation of funds in favour of those ministries that are expected to make the greatest contribution to achieving the stated goals and objectives. Additionally, at the end of each fiscal year, the progress of the policies and plans can be measured against their stated targets to determine if the organization delivered on its promise toward the achievement of the government's overarching objectives. The next Annual Budget can then be adjusted accordingly.

## Constructing the Framework

This framework should comprise three levels:

(1) A *supreme authority* that would be responsible for developing the government's overarching *objectives* with respect to enhancing sustainable development of the Malaysian economy in the energy sector through the expanded use of STI resources.

(2) A *managing authority* that would be responsible for:

- developing the government's specific *goals* with respect to the energy sector and STI resources for the following specific time periods: (1) 2010-2015, (2) 2015-2020, (3) 2020-2030, and (4) 2030 and beyond;
- preparing and disseminating, in a timely manner, the guidelines that define the overarching objectives and goals relative to enhancing sustainable development which each organization that is developing plans and policies must follow;
- reviewing the plans and policies that are developed to see if they focus on meeting the targets and achieving the objectives set by the supreme authority;
- monitoring the activities of the organizations that are developing their policies and plans to identify the causes for any major delays that may be occurring so that it can report to the supreme authority with recommendations regarding the actions needed to ensure that the commitments made by the organizations can be met by the end of the relevant time period; and
- offering "consulting assistance" to the organizations that are developing and implementing the sustainable development policies and plans. This consulting assistance is (1) derived from the knowledge and insight that the managing authority would gain from working with the supreme authority, and (2) intended to improve the quality of the policies and plans and ensure that the implementation of them is efficient and effective.

(3) The *organizations* that would be responsible for specific planning processes. These could be ministries, departments, agencies, special units, etc.

The key to the success of this framework in identifying objectives and targets and ensuring that all policies and plans are guided by these is for all the parties concerned to have the necessary authority to carry out their duties. The study team believes that the National Green Technology Policy (NGTP) provides the governance structure, directional guidance and operating elements needed for such a framework to be successful. Hence, a possible candidate to play the role of the supreme authority in the proposed framework would be the Green Technology Council. The members of the managing authority could be the members of the Green Technology Agency. The organizations in the framework would then be the various line ministries, agencies and special units that are already in existence.

The framework itself is rather simple. The one that would support the country in accelerating sustainable development is embodied in the NGTP document plus two specific additional elements. These elements are a set of requirements and a set of guidelines which the government should observe.

## The Roadmap

Once a high-level framework has been established (this has already been accomplished with the adoption of the NGTP), the first action of the Green Technology Agency must be to develop the roadmap that integrates all the plans/policies that the government currently has or is developing. With this, the Green Technology Council can then use the roadmap to coordinate and prioritize all its energy-related initiatives.

Given the lack of integration, the roadmap-development process requires a detailed review of every single plan/policy. The following for each plan/policy needs to be identified:

- The areas covering energy, SD and STI development and the associated actions proposed for each.
- The degree to which the plan/policy relies on inputs from any other plan/policy.
- The degree to which a sector or an area of activity addressed in the plan overlaps or duplicates other plans/policies.
- The implementation time-line for the actions proposed.
- The resources currently available or planned to carry out the actions proposed.
- The level and nature of effort to be devoted to STI-resource development.

The intended product from this review is a *single* document that provides the Green Technology Council with the following *information*:

- A summary of the main points from each of the plans/policies developed by the government. Only then would there be a single reference point that describes all the major planning activities that are completed or currently underway.
- A determination as to whether a plan/policy overlaps with any other plan/policy (e.g. do the plans/policies cover or impact the same area? How are different organizations contributing to SD planning, STI development or the identification of energy-related opportunities?). This analysis should result in a roadmap that describes the specific inter-relationships between all the energy-related planning processes. By having a basis for rationalizing such processes, a package of plans that do not duplicate efforts and are supportive of each other can be created.
- A comprehensive and integrated roadmap is one that is made up of more than all the separate plans/policies put together into one document. It also indicates (1) the time-lines for specific activities in each of those plans/policies, (2) the lead responsibility for the activities, (3) the outputs from each plan that will be used in other plans, and (4) the key results that are expected to be produced in a specified year in the long term.

It is highly desirable that some of the plans/policies specify the activities or resources devoted to tracking the progress of energy-related technologies. These technologies may be in their basic research stage or at a very early R&D stage. Thus, Malaysia will be continuously updated on what is happening on the R&D front and can decide, in a timely fashion, whether it may want to become involved with the technologies as they mature. In the same way, the country may decide to abandon or reduce efforts devoted to areas that are not developing as expected.

## The Action Plan to Follow the Roadmap

After the development of a roadmap, an action plan is needed to prioritize the areas which will move Malaysia along the path laid out in the roadmap. The study team believes that it should be the responsibility of the Green Technology Agency to prepare the initial draft of this action plan, after which a submission of the action plan can be made to the Green Technology Council for review and deliberation. After the Agency and Council have decided on the content for the action plan, the Agency should then prepare the final version of the plan. This "Roadmap Implementation Action Plan" will then be provided to all organizations so that they would have the necessary guidance to modify their plans accordingly. With this, the organizations can then focus on a prioritized list of areas which the Council has decided are the most important for the current planning cycle. This list would cover STI, SD and various energy-related opportunities.

Important information that should be included in the action plan are:

- A prioritized list, by type and size, of energy-related STI opportunities for adoption in the Malaysian business arena in the period 2010-2020 and the period beyond 2020. Priority must be based on 'best fit' with current and near-term enhancement of the STI resource base. Opportunities to be prioritized must also generate the greatest contribution to sustainable growth.

- An inventory of new energy sources and technologies as well as new ways in which energy can be produced and consumed in the period 2010-2020 and the period beyond 2020.

- Opportunities to reduce energy wastage by changing the energy-waste culture in the country.

- Opportunities which can present dramatic change in the production and consumption of energy.

- STI resources currently available or needed to take advantage of the opportunities.

- An appropriate way to monitor progress in the pursuance of energy-related opportunities.

- Recommendations for enhancing current governmental actions regarding expansion of the STI resource base and the monitoring thereof.

- Opportunities to develop relationships with other parties in the pursuance of energy-related opportunities beyond 10 years.

- Key elements that must be present in the SD-planning process to ensure the production of effective plans.

- A description of the process entailed by *ex-ante* and *ex-post* evaluations used to assess expected and actual results of plans.

In short, the action plan is focussed on identifying resources in terms of need and allocation.

## Implementing the Action Plan

Next, the action plan that is needed to actually follow the roadmap with respect to STI resource enhancement must include the following considerations.

- The action plan must identify specific steps to remove or reduce barriers to technology deployment.
- The action plan will need to ensure that there are steps in the plan that will lead to the adoption and effective enforcement of appropriate energy production and energy use standards.
- Because the action plan to implement the roadmap covers four decades, it is extremely important that the action plan does not foreclose any energy-related options or alternatives.
- The action plan must
  - ➢ identify the specific steps the government will need to take to assign specific responsibilities and accountabilities to ministries and agencies;
  - ➢ establish the relationships between universities, research institutes and the private sector R&D;
  - ➢ allocate lead responsibility for development of specific sectors of the energy industry;
  - ➢ ensure coordination of the current infrastructure and human resource base to focus on the selected opportunities;
  - ➢ identify where additional/new resources will be needed and motivate the programmes needed to produce the resources;
  - ➢ ensure that the programs put in place to develop the opportunities are monitored so that the opportunities are realized; and
  - ➢ ensure that there is a mechanism to continually monitor the energy sector to identify new opportunities and opportunities that are no longer attractive.
- The action plan must detail the steps the government needs to take in order to determine the amount of funding needed. The action plan must also detail the steps needed to ensure that the projects being funded are operated in such a way as to support each other wherever possible to maximize the value derived from the expenditure.
- The action plan must include monitoring measures to (1) identify the extent to which it expects to progress towards achieving the Council's objectives and goals (*ex-ante*), and (2) track the actual results achieved at the end of the planning cycle (*ex-post*).

The action plan with respect to energy-related opportunities must identify those opportunities that should be pursued first in each time frame. It is absolutely essential that the work of identifying and ranking the energy-related opportunities be completed in 12-18 months to provide a "fact basis" for the government to use in deciding where effort and resources should be expended (1) by the government alone, and (2) by the government in cooperation with universities, institutions and private sector companies.

The important information that should be contained in the rollout of the action plan with respect to *sustainable development planning* encompasses:

- A directive requiring each ministry to translate the overall SD plan into its own specific plan and to publish regular progress reports.
- Defining the funding sources and amounts that will be dedicated to supporting the implementation of the SD plan

The important information that should be contained in the rollout of the implementation plan with respect to *STI enhancement* includes:

- Mandating specific programmes to accelerate development of human capital.
  - ➢ Introduce and/or strengthen entrepreneurship courses in the education curriculum;
  - ➢ Promote cross-border exchange of STI talent;
  - ➢ Increase dialogue amongst industries, ministries and universities to identify current and emerging STI needs;
  - ➢ Review incentives to retain the best and brightest STI graduates; and
  - ➢ Restructure the public administrative service for upward mobility of STI-qualified personnel.
- Mandating that priority in all energy-related plans be given to utilizing and increasing home-grown R&D, technology acquisition and innovation in:
  - ➢ Sector technology roadmap development and funding assistance for R&D projects, technology acquisition and innovation;
  - ➢ R&D collaboration programs; and
  - ➢ Techno-entrepreneur development.
- Requiring all energy-related plans to document how they will mainstream STI, nurturing and developing a culture of creative and innovative thinking.
  - ➢ Promote STI policy as one of the (primary) drivers of national development and align it with other development policies;
  - ➢ Identify a lead ministry with respect to the national STI agenda;
  - ➢ Produce the a 5-year technology development plan;
  - ➢ Facilitate the development of hi-tech SMEs; and
  - ➢ Implement an STI awareness campaign.

- Enhance and strengthen alliances between the government, universities, industry and research institutes.
  - Provide a framework for a common platform to coordinate all STI development activities; and
  - Make centres of excellence independent from government procedures.
- Direct the Education Ministry to develop and implement a quality STI-education programme at the primary and secondary school levels, including the plans for staffing this program with competent teachers.
- Establish an application-oriented and innovation-oriented funding mechanism that is independent of the government but overseen by an appropriate government agency.

# CHAPTER ONE | Introduction and Study Background

## Introduction

The Academy of Sciences Malaysia (ASM) has been undertaking a *Mega Science Framework Study For Sustained National Development* covering the period 2011-2050. This study represents a concerted attempt to look at what might happen in the development scenario over the next 40 years as the country continues in its quest to be numbered amongst the developed nations of the world.

The members of the Academy strongly believe that the key to sustained national development lies rooted in the principles and concepts embodied in that area of expertise that has come to be known as STI (science, technology and innovation). As promulgators of objective and rational thinking, the members of the STI community are strongly positioned to make an immense contribution towards the country's stated goals by creating opportunities for enhancing national development through the application of scientific and engineering knowledge. The Academy also believes that the purveyors of the STI concept carry a collective wisdom which can help identify weaknesses in the current development processes. Thus, to attain that coveted developed-nation status as well as sustain it, the powers-that-be are persuaded to make full use of all the relevant scientific and technological know-how and tools available. To this end, the world of STI – both local and foreign – has much to offer.

In the march towards progress, it is not sufficient for the STI community to function as a mere provider of information as and when the need arises. Rather, the community should be relied upon to play a dual pro-active role by (1) utilizing STI principles to frame development issues, and (2) identifying the scientific and technological tools that can drive the various development processes. This position is justified by the obvious fact that decision-makers at all levels need timely and unfettered access to the knowledge-base generated by STI activities. Without such access, it will not be possible to formulate sensible and holistic policies which reflect a clear understanding of the complex technical, economic, social and environmental issues that under-gird sustainable development.

The energy question must take centre stage in any discussion on development. This is because *that ethereal entity known as energy* permeates every aspect of modern living. It is analogous to the circulatory fluid in any living organism. Hence, any study on sustained national development must address all energy-related issues. And there is an added caveat: in these modern times, energy and the environment have become inextricably intertwined. It is in this context that ASM has undertaken the onerous task of studying the energy situation in this country – *where we are now and where we hope to be*. Throughout the study, appropriate attention has been given to environmental concerns. The intent is that the implementation of the recommendations drawn from the study will not only help us attain the developed-nation status we crave but in so doing we will also position ourselves as a responsible segment of the global community.

This Study Report represents the final report of the massive ASM endeavour titled *Mega Science Framework Study For Sustained National Development* (2011-2050) – *The Energy Sector*. A proper discussion on energy entails a host of scientific principles and intricacies, many of which will be mere technical jargon to the average reader. Hence we have sought to produce a volume that expresses all and sundry *in layman's terms*, confining the science and engineering as best we can to a single chapter.

In this first chapter of the Report, the reader is provided with the information necessary to understand the background that has shaped the challenges and opportunities that have arisen in the nation's energy sector. A discussion of this background is an essential starting point. The elements that define these challenges and opportunities will be identified. This will obviously include a candid evaluation of the current energy situation, both locally as well as globally. This is followed by a description of the study in the context of other endeavours being undertaken in the country to deal with sustainable development of the Malaysian economy in the wake of major changes in the energy scene. Next, the objectives of the study will be documented. The overall intent is to give as much credence as possible to the high-level recommendations at the end of the study report. Finally, the professionals whose expertise and laboured discussions formed the substance of the study are identified and acknowledged. It is hoped that their work will be given its rightful place in the unfolding national development scenario.

## The National Background to the Study

The second sitting of the National Innovation Council in November 2007 resulted in the adoption of the National Innovation Model depicted in Figure 1.

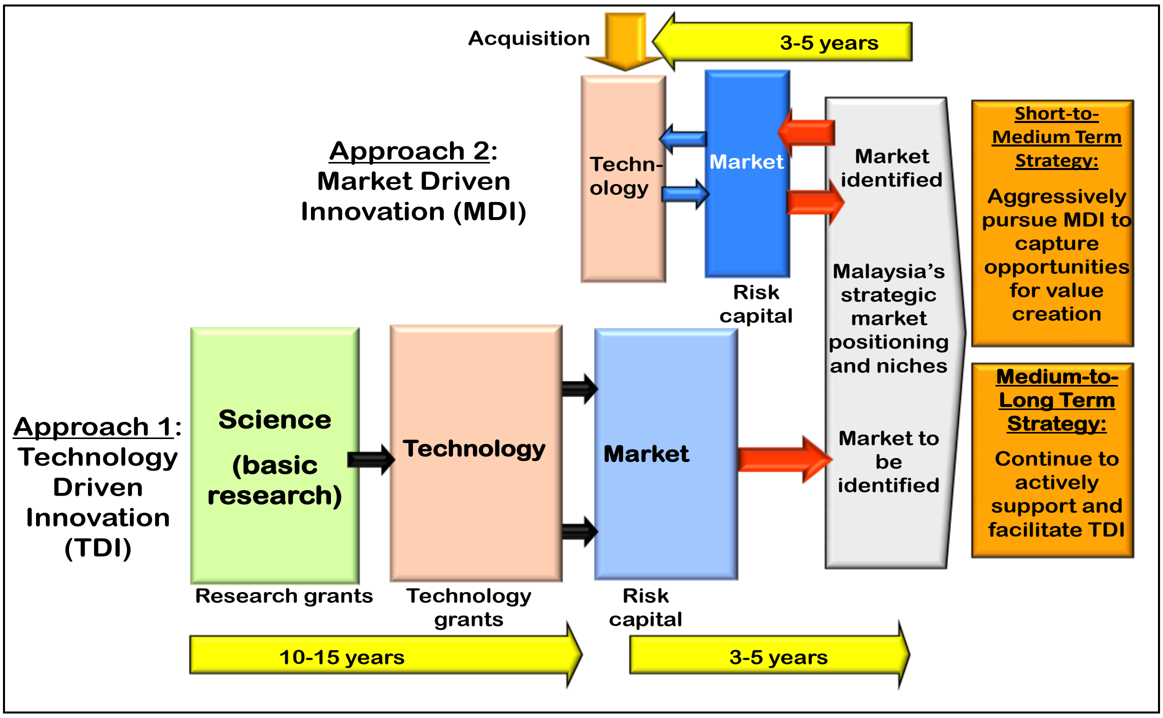



**Figure 1: The National Innovation Model**

Source: "STI Strategic and Action Plan, 2010-2020", Ministry of Science, Technology & Innovation

This model lays a strong foundation for the creation of wealth and societal wellbeing in the country by delineating two possible pathways to drive innovation in the Malaysian economy.

The first approach is research-based and technology-driven and can thus see realization only in the medium term, at the earliest. The STI community can throw its weight behind this approach by spearheading, undertaking and supporting relevant research activities.

The second approach is market-driven and can come to fruition in the short-to-medium term. Underpinning this approach is the acquisition of technology from abroad, much of which will necessitate innovation in adapting the imported know-how to the local situation. Once again, the STI community would naturally be at the forefront of such endeavours.

It has already been established that energy – where we get it from and how we use it – must be at the heart of any discussion on national development. The core issues of the energy question for any country are (1) security and (2) sustainability.

The first of these, energy security, deals with the problem of long-term availability of this vital commodity. Most countries of the world are heavily dependent upon the fast-depleting fossil fuels of coal, oil and natural gas. Malaysia is no exception. There is an urgent need to minimise this dependence by turning to alternative renewable energy resources. The current over-dependence on fossil fuels has the added disadvantage that supplies are often derived from geopolitically sensitive areas. It is clear that these considerations can severely compromise the energy security of this nation.

The second of these issues, sustainability, deals with the need to accommodate the ever-increasing demand for energy that is a direct consequence of economic growth whilst keeping prices affordable as well as minimising any negative impact upon the environment and human health.

The National Green Technology Policy, launched in July 2009, is the latest in a series of government initiatives designed to deal with these and a host of other energy-related concerns. One cornerstone of the policy is that green technology must be a key driver of economic growth for the country. This study gives due regard to the underlying scientific, economic and social principles upon which the policy has been formulated. An overview of the policy appears in Chapter 3.

## The Global Background to the Study

The 2007 publication of the World Energy Council titled, "Deciding the Future: Energy Policy Scenarios to 2050", describes a number of distinct energy-related situations that could develop around the world during the next four decades. The document also lays out the likely consequences associated with each scenario. The reader is directed to Appendix 1.1 for detailed information covering the principal observations, conclusions and recommendations arising from the 2007 meeting of the council in Rome.

The convening of the world body in the Italian capital reached a consensus that any energy outlook must be evaluated in terms of *"The 3A Criteria"*. These are:

- Accessibility – a minimum level of commercial energy services must be accessible to the public at prices that are both affordable and sustainable;
- Availability – there must be long-term continuity of supply as well as quality of service;
- Acceptability – public perception and the environmental impact of all forms of energy utilization must be positive.

The congress also agreed, in principle, upon the following:

- Global energy demand is likely to register a 100% increase by 2050;
- Renewable energy (RE) will make an impact in the 2011-2050 time period but will not dominate any market;
- The changing and complex energy environment over the next 40 years will be managed more successfully through partnerships;
- Demand-side mobilization is absolutely essential to achieving the 3 As;
- Energy intensity is likely to decrease if there is cooperation between the private and public sectors;

- Greenhouse gas (GHG) emissions cannot be controlled without strong government action in each country as well as inter-governmental cooperation;

- More innovation will be needed to reduce the growing imbalance between supply and demand, and governments must play the major role in facilitating this;

- Governments must provide clear and forceful leadership with respect to energy consumption; and

- National policies governing the energy sector must be very clear as to intent and less prescriptive as to means.

There appears to be broad global consensus amongst experts that there are three energy-related pillars of sustainable development. These are:

- Ensure that energy supplies are affordable in order to maintain economic growth – *the economic perspective;*

- Ensure the long-term security of energy supplies – *the security perspective;* and

- Ensure that harmful emissions arising from energy use are minimised – *the environmental perspective.*

Traditional analyses of energy scenarios tend to regard the pursuit of economic, security and environmental interests to be in conflict with each other. However, emerging views on this matter suggest that a reconciliatory stance is possible. Such a position calls for (1) innovative technologies, (2) efficient market mechanisms, and (3) strong policy actions that could develop all three pillars simultaneously. Viewed in this way, the challenge to bring about sustainable growth can be re-framed as the need to identify a spectrum of technologies with good market potential, then leverage market mechanisms and targetted policies in such a way as to unlock this potential.

This energy-related study seeks to address each of the concerns outlined in the preceding discussion of the global background insofar as they prove relevant to the Malaysian situation.

## Other Energy-Related Studies

The *Mega Science Framework Study* on the part of ASM is one of a number of recently completed or ongoing studies intended to (1) identify energy-related opportunities that can contribute to Malaysian economic growth, and (2) suggest how the country can develop or acquire the STI resources needed to take advantage of these opportunities.

Three of the more eminent of these studies are:

- *The Energy Blueprint Study*, a report to the Energy Commission Malaysia carried out by ISIS Malaysia; July 2008;

- *STI Strategic and Action Plan (2010-2020)*, currently under development by MOSTI (the Ministry of Science, Technology & Innovation); commenced July 2009; and

- *A Study to Formulate a New Energy Policy for Malaysia (2008-2030)*, currently being carried out by PA Consultants under contract with the EPU (Economic Planning Unit), Prime Minister's Office; commenced July 2009.

The reader is encouraged to source and review the reports on these studies in conjunction with the ASM *Mega* study. A summary of the MOSTI study is provided in Appendix 1.2. A preliminary report on the EPU study was released in November 2009. That document indicated that while the EPU and ASM studies have several points of departure in terms of the topics covered, they also offer alternative perspectives on areas of common coverage. Appendix 1.3 details these similarities and differences.

## The Objectives of the Study

The single over-arching objective of this study is to establish a high-level framework which will identify the energy-related STI opportunities

- that would best fit the nation's currently available resources;

- that could reasonably be developed during the next 40 years;

- that are likely to generate the greatest amount of sustainable economic growth; and

- that are likely to have potential for the development of new businesses.

The provision of such an information-rich and reliable framework will assist the Government in

- producing a prioritized inventory of actions needed to pursue all the STI opportunities identified;

- formulating robust, well-informed national development strategies and plans that would incorporate these opportunities;

- monitoring the progress of specific STI projects being undertaken;

- deciding the areas in which financial support should be continued, re-directed or terminated; and

- legislating measures to reduce the wastage of energy in the country and change the energy-waste culture.

The energy-related STI opportunities identified through the study may be categorised according to the following *dimensional* criteria:

- *When* are the opportunities to be pursued – in the short-term (2011-2020), or in the medium-term (2021-2030), or in the long-term (2031-2050)?

- *How* will the opportunities be employed – to meet the domestic energy needs of the country, or to launch new businesses that directly contribute to economic growth, or both?

- *Who* will develop these opportunities – universities and affiliated institutes (basic research), GLCs and private companies (commercialization)?

For each of the time frames indicated, the study identifies the range of energy-related STI opportunities that are expected to be available for the residential, commercial, industrial and transportation markets. This deals with the *when* dimension.

The STI opportunities are also split into those that would raise energy efficiency in the four domestic markets and those that the country could invest in to create new businesses, both domestic and offshore. This deals with the *how* dimension.

The study also makes recommendations on the distribution of responsibilities for developing and commercializing each STI opportunity. This deals with the *who* dimension.

## The Study Team

The Study Team comprised the following eminent persons and professionals drawn from the Malaysian energy industry:

- Y.Bhg. Dato' (Dr.) Ir. Annas Hj. Mohd. Nor, Project Director

- Prof. Ir. Dr. Abd. Halim Shamsuddin, Power & Related Energy

- Dr. Mohd. Farid Mohd. Amin, Oil & Gas

- Ir. Chen Thiam Leong, Consumption & Utilization

- Dr. Pola Singh, Transportation (until December 2009)

- Dr. W. J. Leininger, Advisor to the Government, STI and Sustainable Development Policies, High-Level Framework to Assist Government to meet Energy-Related Challenges and Realize Opportunities

- Ir. Auniah Ali, Project Coordinator

- Pn. Murtadza Mohd. Kasim, Project Coordinator

The Members of the Team wish to acknowledge and record their heartfelt thanks and appreciation to ASM for giving them the mandate and opportunity to undertake this *Mega Science Framework Study for Sustained National Development (2010-2050) – the Energy Sector*. The Team also wishes to record, with gratitude, the special contributions in knowledge, wisdom, experience and perspective made by the following persons:

- YB Dato' Sri Peter Chin Fah Kui, Minister of Energy, Green Technology and Water;
- Y.Bhg. Tan Sri Leo Moggie, Chairman, TNB
- Y.Bhg. Dato' Sri Che Khalib Mohamad Noh, President and CEO, TNB
- Y.Bhg. Datuk (Dr) Abdul Rahim Haji Hashim, President, International Gas Union
- Y.Bhg. Datuk Dr. Daud Mohamad, Director General, Agensi Nuklear Malaysia
- Encik Ahmad Zairin Ismail, CEO, Malaysia Green Technology Corporation (formerly Pusat Tenaga Malaysia)
- Dr. Mohd. Zamzam Jaafar, Head, Nuclear Energy, TNB
- Dr. Fereidoon P. Sioshansi, President, Menlo Energy Economics, USA

The Team Members are also thankful for the invaluable input and suggestions made by a number of individuals and agencies during workshops and consultation sessions attended by the nation's energy stakeholders. A full listing of those who participated in these sessions is provided in Appendix 1.4.

# CHAPTER TWO
# The Science of Energy

## What is energy?

Energy is the most fundamental physical thing in the universe. Without it, nothing is! It is a scientific quantity with a unit. The standard unit for energy is the joule. But most people seem to prefer the calorie.

Scientists measure energy in joules. Just how large is one joule of energy? Well, try raising a brick from the ground to your waist. If it is a standard brick and you are an average person, you have just done about 20 joules of work. In other words, you have just used up about 20 joules of the energy that was being stored in your tissues.

Now, 1 calorie = 4.2 joules. So the earlier figure in calories is 4.8. If you are a 60 kilogramme person and you climb up a standard flight of stairs, you would have used up about 1800 joules or 430 calories. Leave a 60-watt bulb burning for 1 hour and you would have used 216000 joules of energy. There is a simpler way of saying this: 216 kilojoules, since 1 kilojoule is 1000 joules. Your instant shower heater is an energy guzzler. If it is rated at 2500 watts and is kept running for 5 minutes, you would have used nearly ¾ million joules of energy just for a shower!

## Units Used in the Energy Industry

Clearly, the joule is a small unit of energy. It takes about a joule of energy to stretch out your arm vertically. Given the way in which the average person uses energy, we would have to use very large numbers to represent ordinary consumption figures in joules. Here, the physicist comes to the rescue. Enter the kilowatt-hour (kWh). 1 kWh is 3.6 million joules.

Electricity supply companies such as TNB use the kWh as the basis for calculating your energy bill. TNB refers to this as one *unit* of electrical-energy consumption. At minimum rates, you would owe TNB 21.8 sen for using one unit of electrical energy.

Air-conditioners are the big users of electricity in the energy scene. For example, a 1½ horsepower medium-sized split unit, in scientific terms, has a power of 1.1 kilowatts. If left on for 6 hours, 6.6 kilowatt-hours of power would have been used. This is equivalent to 6.6 units, costing RM1.44 (at the current tariff rates).

The oil industry uses a unit called a *barrel* as a measure of quantity. One barrel of oil has a volume of 42 US gallons or 160 litres. The energy worth of this barrel of oil is

6.1 gigajoules (that's 6,100,000,000 joules) or 1.7 megawatt-hours (which is 1,700 kWh).

Oil is a sort of *standard bearer* for the energy industry. So when the experts wish to compare fuels with one another, they speak in terms of *boe* or *barrels of oil equivalent.* This means that they 'convert' all other fuels into their equivalents in terms of oil. When the amounts are large, the boe is replaced by the *toe* or *tonnes of oil equivalent.* 1 toe = 7.4 boe. 1 ktoe = 7400 boe.

## Consumption, Conversion and Efficiency

Everyone who has been exposed to the sciences knows about an awesome principle called *the law of conservation of energy*. This law states that you cannot create nor destroy energy; you can simply convert it from one form into another. So, in a very real sense, energy can never really be consumed. To consume one form of energy is simply to *convert* it into another less useful form.

In the face of depleting energy resources, energy efficiency has become something of a watchword. There is an urgent need to reduce the amount of energy required to accomplish a given purpose. For example, a 40-watt incandescent lamp and a fluorescent one of the same rating will consume the same electrical power but the latter will produce four times as much illumination. This makes it four times more efficient than the former. Turning the argument around, to provide as much illumination as a 40-watt incandescent lamp, a fluorescent one needs to consume only 10 watts of electrical power.

## Fossil Fuels

Fossils are plant and animal remains that were buried in the Earth's crust eons ago. Subjection to immense pressure and temperature has chemically altered these remains into coal, oil (petroleum) and natural gas. Hence the term *fossil fuels*.

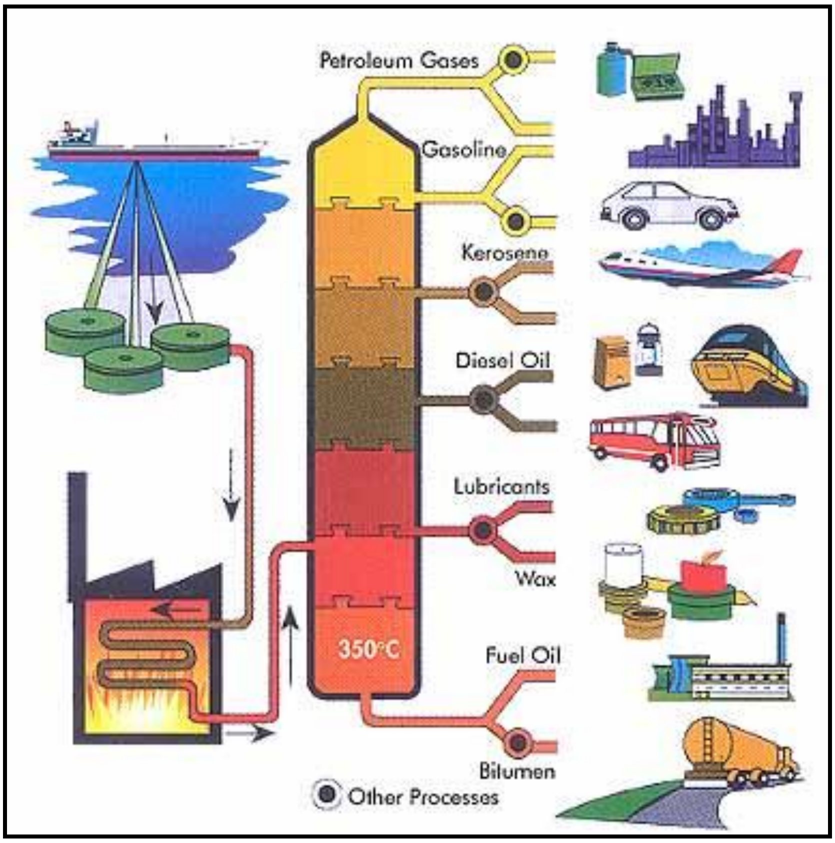
These materials are vital to modern living primarily because the combustion of them releases heat energy for a variety of purposes. The US Energy Information Administration (EIA) reveals that in 2007, fossil fuels accounted for 86.4% of the world's primary energy consumption. In particular, about 80% of the world's electrical power comes from thermal power stations in which these fuels are burned to produce steam. At the moment, fossil fuels are unrivalled in the amount of energy they yield for every kilogramme of material burned.

There are two major drawbacks to the utilisation of fossil fuels. The first of these is environmental pollution resulting from the copious amounts of carbon dioxide which they release upon combustion. This contributes to the greenhouse effect which results in global warming. The second drawback is that fossil fuels are a non-renewable resource. They will soon be depleted by the high rate at which we are extracting and using them. These two factors have resulted in a global movement towards developing renewable energy resources to meet the ever-increasing energy needs of the world.

Of the three fossil fuels, coal and natural gas are used mainly in their original forms with some physical modification to aid combustion. Crude oil stands apart from its fossil 'cousins' in that it is hardly ever burned as a fuel. This is because it has a variety of components called 'fractions', each of which is indispensable to a specific industry. The separation of these fractions is achieved by a process called distillation which takes place in an oil refinery (Figure 2.1). The crude oil is heated until it evaporates and the vapour is sent up a fractionating column in which stage-by-stage cooling allows the fractions to separate from each other.

Figure 2.2 shows what a fractionating column looks like inside and identifies the transportation industry as the dominant user of the various fractions.

**Figure 2.1: An Oil Refinery**




Source: [www.sapref.com](http://www.sapref.com)

**Figure 2.2: The Fractionating Column in an Oil Refinery**

## Electricity

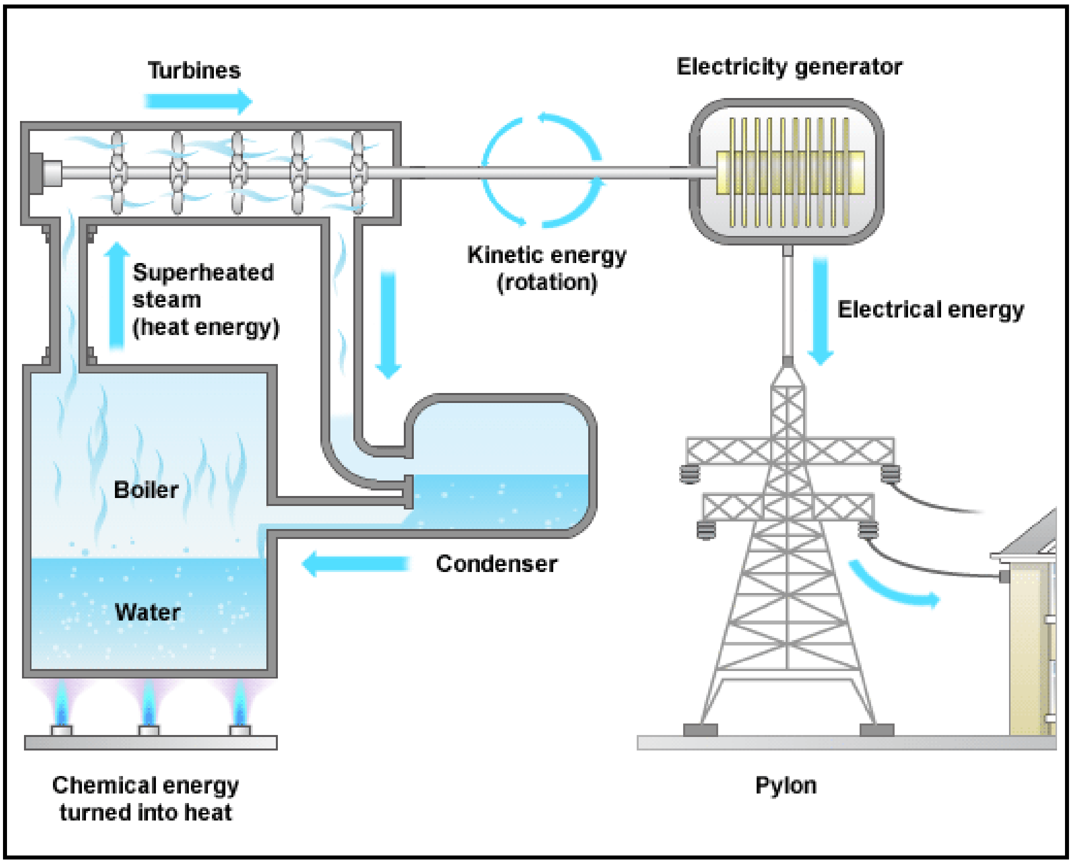
Electricity is the most versatile form of energy known to man. It is easily converted – generally at high efficiency – into just about every other form of energy known. It is for this reason, perhaps, that it is the one form of energy that has come to define what modern life is all about.

## The Generation of Electricity

There are various ways of generating electricity. The conventional method uses the principle of electromagnetic induction in which a coil of wire rotating in a magnetic field produces a voltage. Such an arrangement is called a generator. Since electricity is a form of energy, it follows that the energy needed to turn the generator must be drawn from a suitable source.

## Thermal Power Stations

Approximately 80% of the world's electricity is generated in *thermal power stations*. Figure 2.3 is a schematic diagram of such a facility. These stations, also called plants, are large installations in which huge amounts of heat energy are released by the burning of fossil fuels (coal, oil or natural gas) or by nuclear fission. This heat energy is used to boil water under extremely high pressure, typically 200 times higher than atmospheric pressure, to produce *superheated* steam. When this high-energy steam is directed onto the stainless steel blades of a turbine (Figure 2.4), rotary motion ensues. The turbine is essentially a fan in reverse. A generator mounted on that same shaft produces electricity. Thus, a steam turbine essentially converts the heat energy from the pressurized steam into rotational kinetic energy and a generator takes over from there.




Source: [www.bbc.co.uk](http://www.bbc.co.uk)

**Figure 2.3: A Schematic Diagram of a Thermal Power Station**

Source: montaraventures.com

**Figure 2.4: A Steam Turbine Used in A Thermal Power Station**

## Hydroelectric Power Stations

Like a thermal power station, a hydroelectric power station retains the turbine-and-generator arrangement, as depicted in Figure 2.5. However, it derives the energy to drive the turbines in a totally different way. Water stored in an artificial lake behind a dam rushes through a penstock upon the opening of a sluice gate (Figure 2.6). This is a much cleaner arrangement than the previous one with the added advantage that the ‘fuel’ – the water! – is absolutely free of charge. It is in this sense that hydroelectricity is a renewable form of energy – the water that runs through the turbines will make its way to the sea but will return to the dam through evaporation and precipitation. Furthermore, hydroelectric power stations are highly efficient installations, returning an 85% efficiency figure compared to 35% for the thermal one. And, perhaps best of all in our carbon-constrained world, there is no direct emission of carbon dioxide in any of the processes involved.

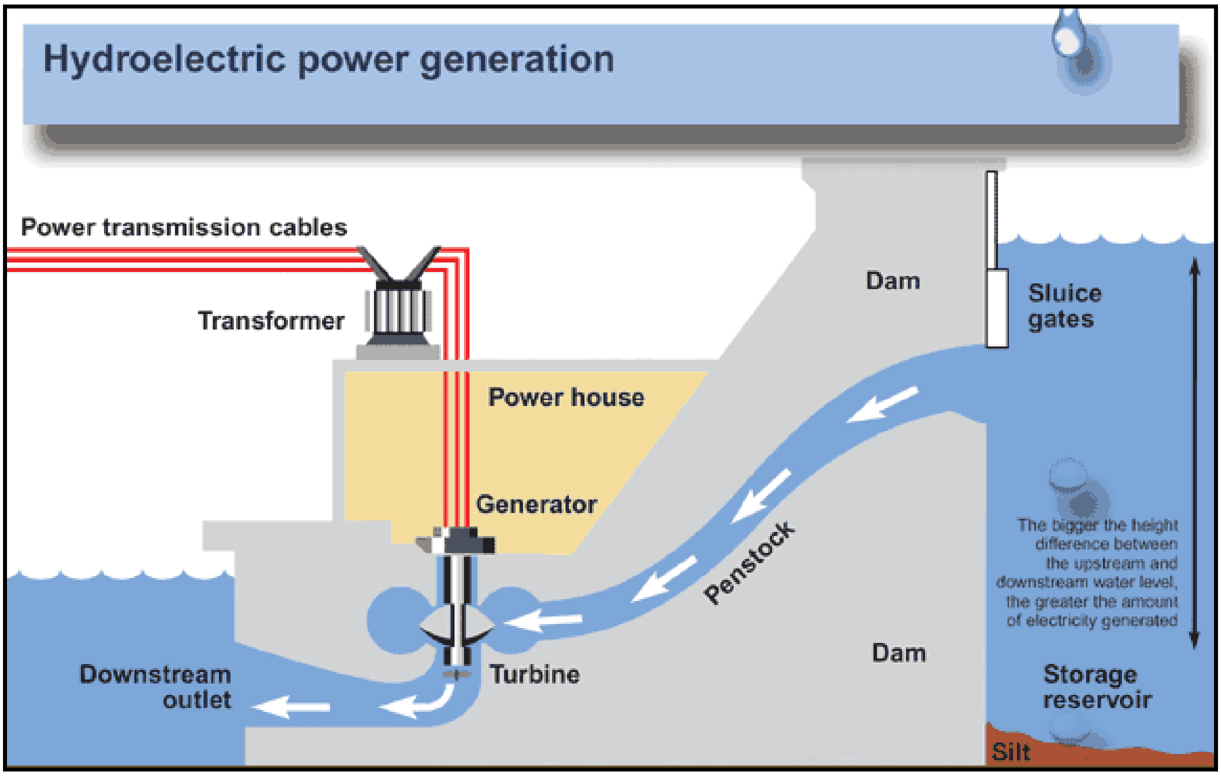



**Figure 2.5: A Schematic Diagram of a Hydroelectric Power Station**

Source: electricalandelectronics.org

**Figure 2.6: A Photograph of A Hydroelectric Power Station**

Source: ecoble.com

The major drawback of any hydroelectric facility is, of course, the permanent ecological damage resulting from the flooding of a river basin. Is this a price worth paying in the name of development? The debate on that controversy rages on and on.

## The National Grid

Figure 2.7 shows a familiar sight the world over – the high-voltage transmission lines of an electrical grid. In a small country like Malaysia, the grid is national in scope.

A National Grid is a system of electrical cables strung up high above the ground on steel pylons. In principle, the grid connects all the power stations in a small country in that each station feeds the electrical energy it generates into the grid. In this way, engineers can direct electrical power to where it is needed most. Each urban centre essentially draws power from the grid and not from individual generating stations.

**Figure 2.7: Transmission Lines of the National Grid**

Source: farm1.static.flickr.com

In Malaysia, the typical voltages that can be found on the grid are 66, 132, 264 and 396 kilovolts. (I kilovolt = 1000 volts.) Scientists and engineers understand the need for these high – albeit dangerous – voltages. Without them, much of the electrical energy generated in our power stations at great cost will simply be wasted as heat in the transmission cables.

## Solar Energy

The ancient Greek name for the sun is Sol from which the term solar is derived. Solar energy thus refers to the energy we receive from the sun.

The average intensity of solar radiation reaching the surface of the Earth in Malaysia is estimated to be 500 watts per square metre. This means that each square metre of surface receives 500 joules of solar energy in one second. Assuming that the sun shines for approximately 12 hours daily, then the solar energy received in one day is 500x12x3600 or approximately 22 million joules. This is a huge amount of energy and it is absolutely free! As such, solar energy represents the best option for the long-term energy security of the world. Malaysia's location just north of the Equator makes it an ideal location for the development of a range of solar technologies.

## Solar Heating

The *flat-plate collector* is one of the most common devices used to harness the *heating* or thermal properties of solar radiation directly. Figure 2.8 shows a typical rooftop version. The sun's rays pass right through a glass cover and are absorbed by water that circulates inside a set of blackened copper tubes set against a matt black surface. Cold water that is circulated through the tubes becomes hot and can be directed into the house or building for various heating purposes.

**Figure 2.8: A Solar Flat-Plate Collector**

Source: HubPages.com

## Solar Photovoltaic Energy

The photovoltaic or PV cell is a device that converts solar energy into electricity. The science of how such a cell works is quite a complicated matter as Figure 2.9 depicts. Different layers of silicon-based semiconductor receive photons or tiny 'packets' of light energy which liberate 'holes' and electrons from the crystal structure. Consequently, a small voltage of about 0.5 volt appears across the positive and negative contacts. When a current flows, a power of about I watt becomes available.

While not much can be achieved with one watt and half a volt, arrays of such cells numbering hundreds or even thousands can produce a substantial amount of electrical power. Figure 2.10 shows one such array.

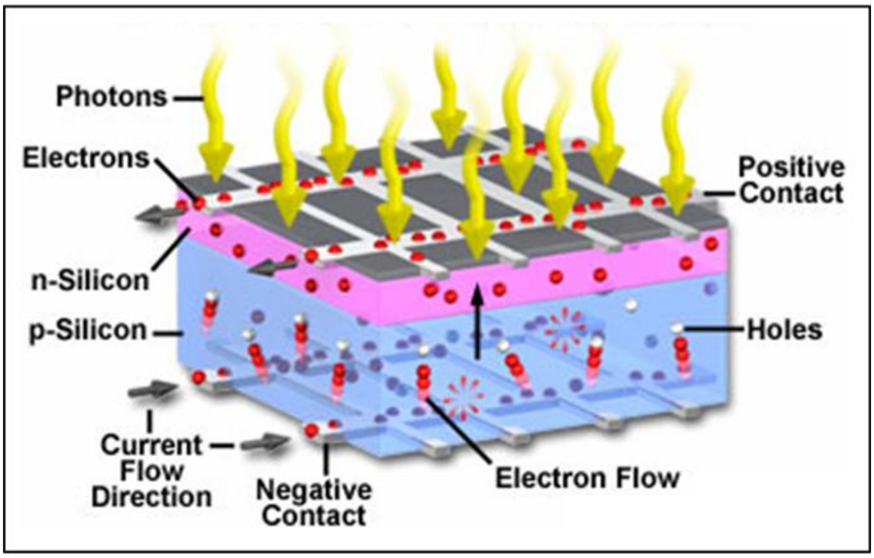



**Figure 2.9: Light Photons Creating A Voltage**
Source: www.olympusmicro.com

## Solar Cooling

While it is not immediately obvious, solar energy can also be used for cooling. We call this solar thermal cooling (STC). The conventional way to achieve STC is to use a large array of photovoltaic cells to provide electrical power to a motor which drives a conventional compressor. This method is best applied to residential and small commercial buildings.

Passive STC is an automatic by-product of conventional solar flat-plate collectors absorbing heat energy from the sun's rays to heat up water and thus preventing them from entering a building. But active STC is another matter altogether. Here, evacuated-tube collectors are used. Figure 2.10 shows such a system of tubes. Their internal design allows for the circulation of a refrigerant based on the materials lithium and bromine. When one end of the system of expansion/condensation pipes is heated by the sun, the other ends get cold. Blowing air over this end produces a cooling effect.

www.ecoyeco.com

**Figure 2.10: An Evacuated-Tube STC System**

## Wind Power

Winds carry energy that can be harnessed usefully. The familiar old windmills of the Dutch landscape were used to convert the energy of the wind into mechanical power to drive mills and other machinery. Modern wind turbines utilize the energy carried by the wind to generate electricity. They essentially convert the relatively linear motion of the air into rotary motion of a shaft on which an electrical generator is mounted. The energy is free-of-charge but the technology is currently expensive.

Wind turbines vary in their capacity to generate electricity. Large turbines can produce anything from 0.5 to 2 megawatts apiece. Figure 2.11 shows such a turbine. A wind farm is a huge facility that constitutes a large number of such turbines with a total capacity of a few hundred megawatts. Such farms are usually located in remote regions and the electricity derived from them can be connected into the National Grid.

**Figure 2.11: A Large Wind Turbine**

Source: 3.bp.blogspot.com

Smaller turbines with outputs of 25 kilowatts or can be sited virtually anywhere and can supply electricity to a small - usually remote – community.

Wind energy is a marvellous alternative to fossil fuels. It is renewable and pollution-free. The whirring noise is considered a form of noise pollution by some quarters.

## Biomass

Biomass is essentially biological material such as wood and waste that come from dead or living organisms. The conventional way to obtain energy from biomass is by incineration. This releases fair amounts of heat energy which can be used for heating or for the generation of electricity in a thermal power installation.

The largest source of biomass energy comes from 'black liquor', a waste product of the pulp, paper and paperboard industry. The second largest source is waste energy which comes in the form of landfill gases and municipal solid waste. Biomass alcohol (i.e. ethanol) can be derived from certain crops such as sugarcane and corn.

## Geothermal Energy

Geothermal energy originates from the Earth's core. It is believed to be due mainly to the radioactive decay of minerals and to 'inner' seismic activity. Consequently, in many regions of the world, the geothermal gradient (i.e. the rate at which temperature rises with depth) can be much larger than the average of 30°C per kilometre.

The principle of operation of a geothermal power plant is very simple, as shown in Figure 2.12. Water at surface temperature is pumped into very deep boreholes that have been made into the underlying rock. The huge underground reserves of thermal energy cause the water to boil and gush forth as steam. In many cases, this is superheated steam with sufficient energy to drive turbines as happens in a conventional thermal power station.

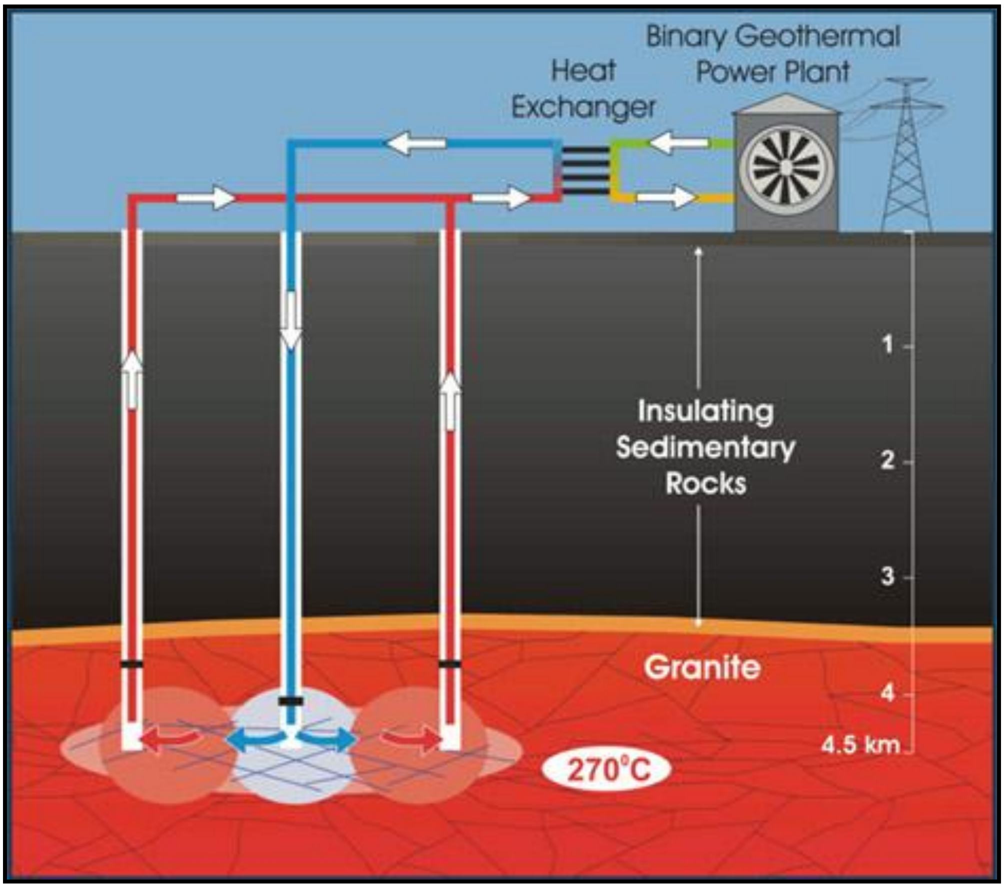



**Figure 2.12. A Geothermal Power Scheme**

Source: Australian Geothermal Energy Association

Geothermal power is cost effective, reliable, sustainable, and environmentally friendly. Alas, the best geothermal fields are also those that are in the vicinity of tectonic-plate boundaries.

## Wave Energy

Waves carry limitless amounts of energy. Unlike solar energy which is available in daily cycles, waves approach shorelines on an endless basis, their power varying only slightly with the ebb and flow of the tides.

The principle behind wave energy is to find a way to harness the oscillatory motion of the waves and convert this into electrical energy.

The Pelamis wave-power generator depicted in Figure 2.13 is one such device. Hinged, cylindrical, floating sections oscillate up and down with the passing of each wave along their lengths. This oscillatory motion is used to pump hydraulic oil in one direction. This oil drives a turbine which drives a generator.

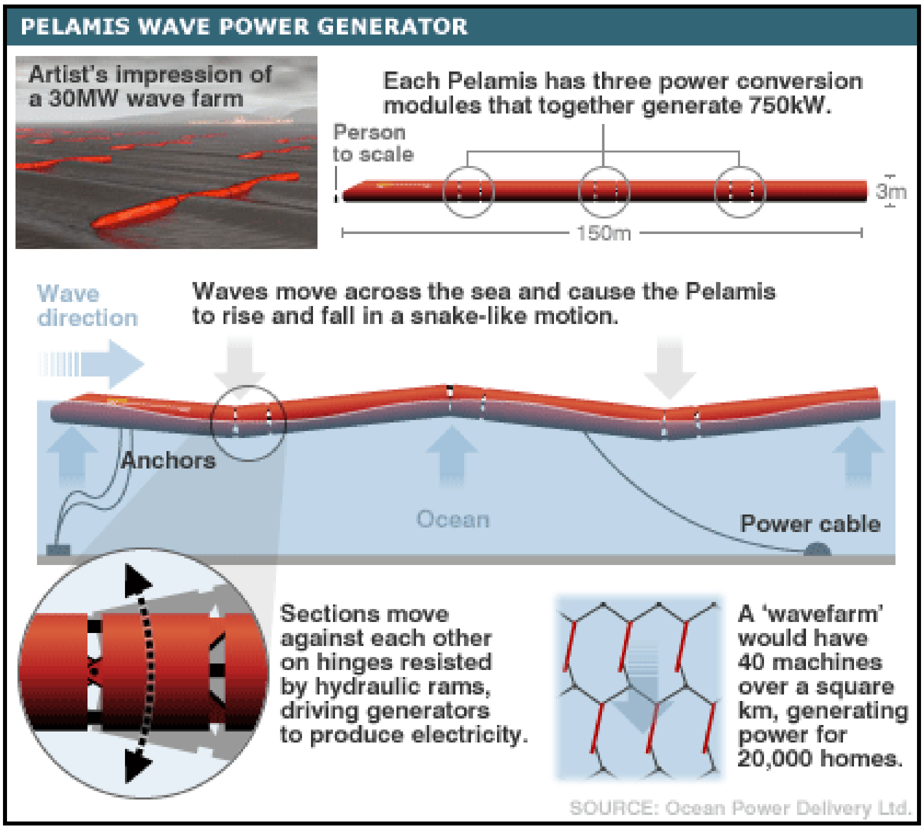



**Figure 2.13: A Pelamis Wave-Power Generator**

Source: agmetalminer.com

## Ocean Thermal Energy Conversion (OTEC)

OTEC is an emerging technology that exploits the temperature difference between warm surface water and cold deep-sea water. The former is pumped through a 'heat exchanger' where it vaporises a liquid with a low boiling point, typically ammonia. This expanding vapour turns a turbine-generator system which produces electricity. The vapour then enters another heat exchanger where it is cooled by cold deep-sea water. This converts it back into a liquid and the cycle is ready to be repeated endlessly. Figure 2.14 shows the scheme.

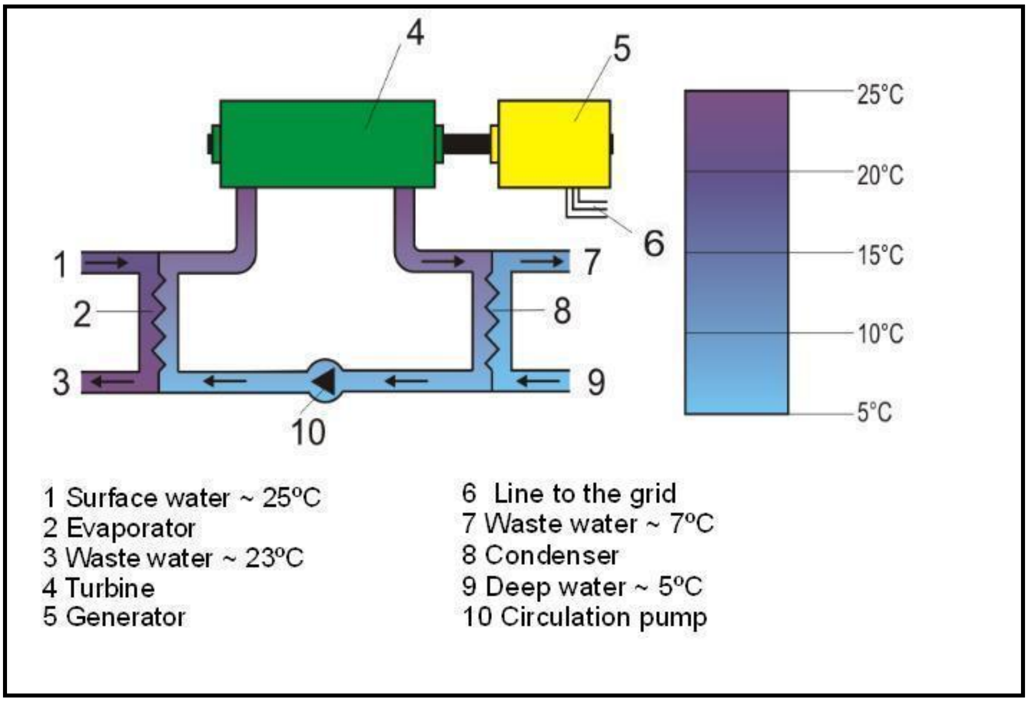



**Figure 2.14: A Typical OTEC Scheme**

Source: Wikipedia

## Hydrogen Fuel Cells

A hydrogen fuel cell is an electrochemical device that uses hydrogen gas as a 'fuel' to convert energy into electricity. The design of such a cell is shown schematically in Figure 2.15.

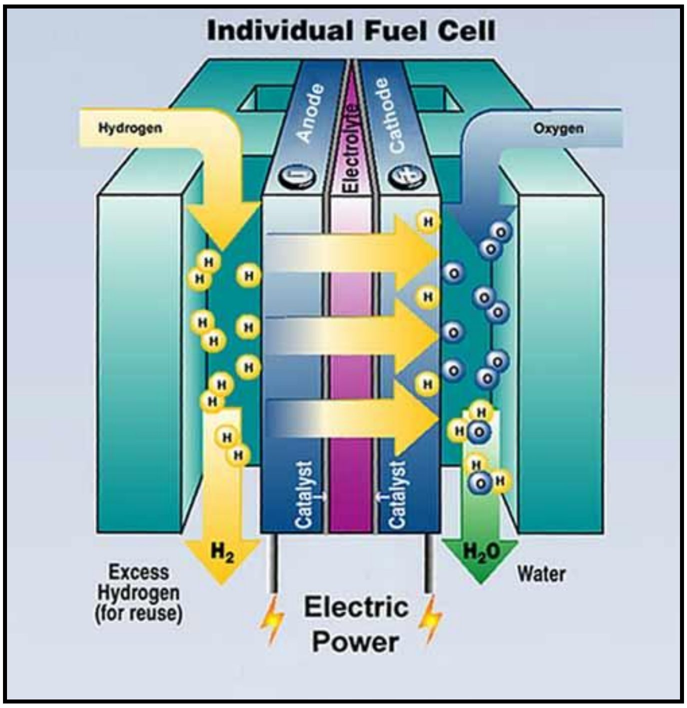



**Figure 2.15: A Hydrogen Fuel Cell**

Source: www.hotcellularphone.com

Like all cells, the hydrogen fuel cell comprises three segments which are 'sandwiched' together: the anode, the electrolyte, and the cathode. A metal such as platinum acts as a catalyst to split hydrogen molecules into positive ions and electrons. The freed electrons now flow out of the cell to deliver electrical energy to a suitable 'load'. Upon re-entry, these electrons merely re-combine with the positive ions and oxygen present to form water. This process goes on for as long as a supply of hydrogen gas exists.

## The Greenhouse Effect

The greenhouse effect is a natural phenomenon in which thermal radiation from a planet's surface is absorbed by certain gases in the atmosphere and re-radiated back onto the surface. The overall effect is the retention of thermal energy within the planet's atmosphere resulting in a surface temperature that is higher than it would have been in the absence of those gases. Figure 2.16 clearly illustrates the principle.

In contradistinction to the process described above, the greenhouse effect is not 'all bad'. On the contrary, it plays a major role in the Earth's day-and-night cycle: without it, those regions of the Earth which are not exposed to solar radiation (i.e. those regions experiencing night time) will quickly radiate a large proportion of their thermal energy into outer space causing surface temperatures to plummet! This means that the greenhouse effect is in essence a good thing. The prevailing concern today is not about eliminating this effect. It is about a delicate balance going wrong due to the presence of excessive amounts of carbon dioxide, methane and the like.

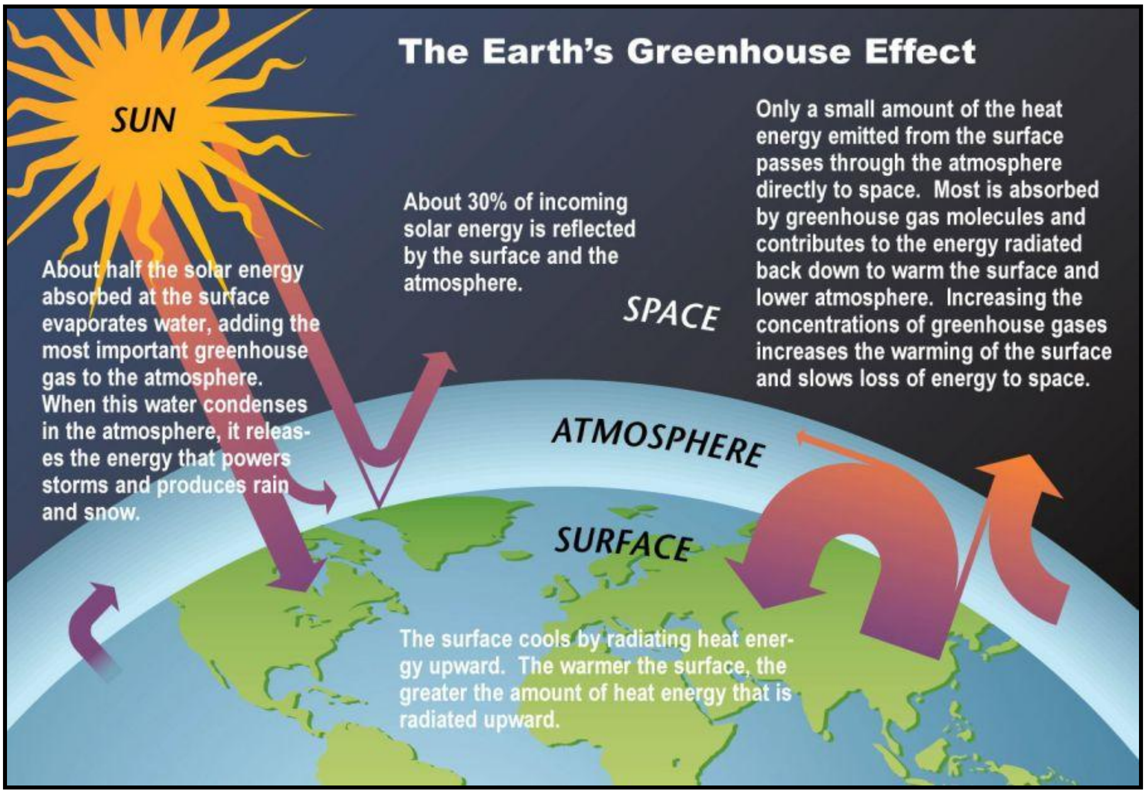



**Figure 2.16: The Earth's Greenhouse Effect**

Source: www.msu.edu

# CHAPTER THREE

# National Plans and Policies

The watchword during the final decades of the twentieth century was development. Almost every independent nation around the globe had a similar agenda. As that era ended and a new millennium dawned, that watchword began to incorporate a somewhat burdensome element as the phrase *sustainable development* came into vogue. To move a nation forward in its march of progress was one thing. To do so in a responsible manner – thinking not only of the welfare of the present generation but of those to come – was another thing altogether.

Sustainable development is not a spontaneous phenomenon, nor does it happen easily. It is not a natural outcome of growth. It has to be thought about, planned and debated in a series of inter-twined processes that could take months or even years. This kind of endeavour is called *crafting a sustainable development plan.*

In this chapter, the efforts hitherto made by the Malaysian government and its various agencies in the vital area of *national sustainable development planning* will be analyzed. There was obviously a great deal of foresight and wisdom carried in the minds of those who laid down plans for the nation's benefit, and this will be lauded. However, it will also be necessary to deal with the many concerns that have been raised over the years with regard to the planning efforts. These concerns reflect perceived weaknesses plaguing the planning system that is currently in place, and these will have to be clearly identified. The objective of such an analysis will be to suggest improvements in the planning processes so that responsible development far into the foreseeable future can be guaranteed.

Figure 3.1 provides an overview of the comprehensive plans and policies that have been formulated by the Malaysian Government since independence. These are carefully crafted documents that have guided the nation's development over the years. Some of them deal directly with the energy question while others involve a significant energy-related component. Inherent in all of these documents have been elements of regulatory and institutional frameworks that have proven essential for managing the various development processes across five decades.

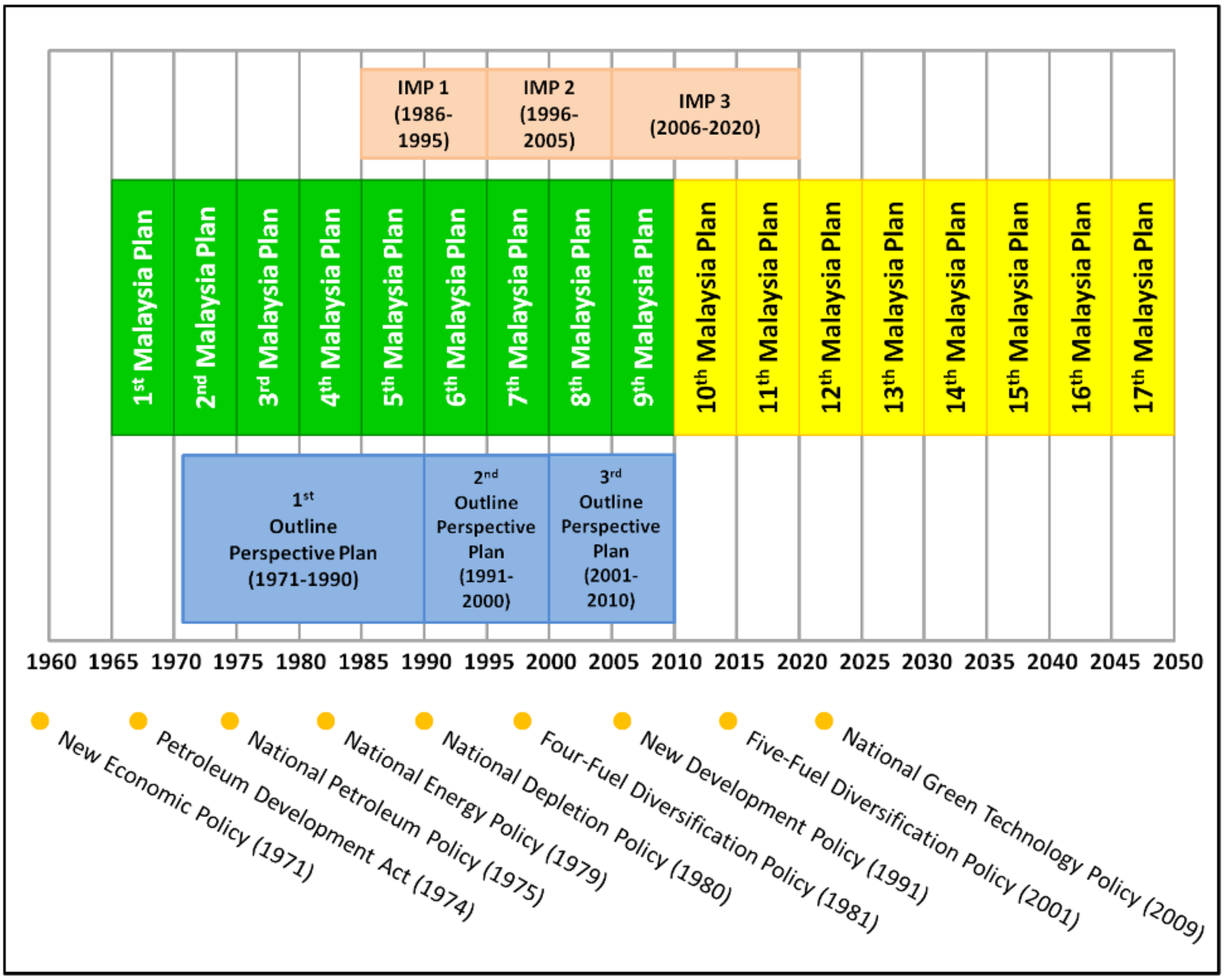



**Figure 3.1: Government Plans and Policies**

Source: Study Team

What follows is an attempt to discuss most of these plans and policies, some fleetingly and others in more detail, insofar as each one impinges upon the issues at hand.

## The Outline Perspective Plans (OPP 1, OPP 2 and OPP 3)

These broad-based big-picture plans were designed to serve the over-arching purpose of guiding the overall multi-faceted development of the country. At the core of the OPP 1 was the New Economic Policy (1971) which was formulated in the aftermath of the darkest moments in our then fledgling nation's history. The plan was aimed at promoting growth with equity and achieving national unity through the eradication of poverty and the re-structuring of society. Its successor, the OPP 2, was drafted around the New Development Policy (1991), building upon the achievements of the OPP 1 to correct social and economic imbalances within the context of an expanding economy. Those efforts have not only been focusing on achieving stated numerical targets of equity re-structuring and bumiputra ownership of corporate wealth but also on achieving a more even-handed distribution of income throughout the country. The development strategy of the OPP 2 period was built upon a number of principles, one of which was the need to address environmental concerns. The document called for "prudent management of natural resources and ecology as well as the preservation of natural beauty and a clean environment, to ensure sustainable development for the present and future generations". Thus did environmental programmes launched under the OPP 2 emphasize the need to establish a clean and healthy environment with ecological and climatic stability. While the plan encouraged the exploitation of natural resources for economic purposes, it stipulated that this had to be done responsibly so as to safeguard the needs of future generations. This is a vital point to carry through the rest of our discussion as all other plans and policies formulated during the OPP 2 time-frame had to adhere to its guiding principles. It will thus be correct to view the OPP 2 as the guardian of the concept of sustainable development.

In 2001, the OPP 3 picked up where its predecessor left off, painting an extended picture of the expectations in the development landscape. The plan clearly identified some important things that had to be done during the opening decade of the new millennium. Most notable amongst these were the building of human capital, increasing productivity, and enhancing the national capacity for knowledge acquisition and utilization in order to achieve sustainable economic development based on STI (science, technology and innovation) resources. The following are some of the target areas identified in the plan.

- Strengthen human capital development to produce a competent, productive and knowledgeable workforce.

- Emphasize product innovation, and research and development (R&D) in this direction.

- Build an indigenous capability to develop advanced technologies, new products and services.

- Explore the venture capital industry as a source of equity capital for knowledge-based start-up companies.

- Increase productivity by upgrading skills, adopting improved management practices and developing the national STI resource base through R&D.

- Expand the entrepreneurial and technopreneurial capacity in the country.

- Pursue environmentally-friendly sustainable development.

In spite of the stated targets, real progress in these vital areas has, however, been minimal throughout the decade. Clearly, the successor of the OPP 3 will need to identify and deal with what went wrong if it is to enjoy greater success.

## The Industrial Master Plans (IMP 1, IMP 2 and IMP 3)

The thrust of the IMP 1 was to lay the foundation for the manufacturing industry to become the leading growth sector of the Malaysian economy. Central to the success of the plan was the sufficiency of energy supplies to drive the frenetic pace of manufacturing activities that was anticipated.

The IMP 2 made it imperative for the nation to focus on developing technology, business incentives and support services. It stipulated the importance of the correct approach to development planning which implied the need to set up a special committee tasked with drafting viable industrial policy and monitoring progress towards the achievement of national goals and objectives. The plan noted that Malaysia already had a *Promotion of Investments Act* that could be used to accelerate business development, in addition to its *Income Tax Act* that provided incentives for skills training, R&D and re-investment by the business community. It firmly stipulated that sustainable growth could be achieved only by increasing the quantity and quality of human capital, and by enhancing indigenous R&D capabilities. The plan also identified the value chain that had to be followed by all energy-related research endeavours in order to capture the commercial opportunities that might have arisen thereof. It identified this value chain as being:

- research and development;
- design and prototyping;
- product development;
- basic processes;
- conventional production;
- distribution and logistics; and
- marketing.

Another intent of the IMP 2 was to further develop the manufacturing sector by strengthening industrial linkages, increasing value-added activities and enhancing productivity. *Implied here was the need for an even more copious supply of energy.*

The IMP3, currently in force, targets about a dozen manufacturing industries for further development. Several of its many strategic thrusts are related either directly or indirectly to the energy question. These thrusts stress the importance of:

- nurturing domestic companies, including GLCs and SMEs, to become globally competitive;
- encouraging capable domestic companies to expand into potential growth areas;
- establishing fully equipped high-technology parks;
- developing the country into a regional hub for selected areas such as biotechnology and algae biofuel;

- expanding the local solar photovoltaic (PV) manufacturing capacity;

- accelerating the application of knowledge-intensive technologies in energy utilization;

- fostering collaboration between universities, research institutes, technology parks and industries;

- developing innovative and creative human capital; and

- strengthening the role of private sector insitutions such as trade and industry associations.

The IMP 3 clearly aims to achieve long-term global competitiveness of Malaysian-made goods through transformation and innovation of the manufacturing and services sectors. *This far-reaching objective demands that energy be utilized much more efficiently than ever before.*

## The Eighth and Ninth Malaysia Plans (8MP and 9MP)

Figure 3.2 highlights the differences between the 8th and 9th Malaysia Plans with respect to how they aimed to address energy-related issues in the country.

| 8th Malaysia Plan | 9th Malaysia Plan |
|---|---|
| • Ensure adequacy and security of fuel supply as well as promote the utilisation of natural gas and renewable energy.<br>• Ensure adequacy of electricity supply and improved productivity/efficiency.<br>• Encourage efficient utilisation of energy nationwide, especially in the industrial and commercial sectors.<br>• Develop energy-related industries and increase local content in these.<br>• Promote Malaysia as a hub for energy-related engineering. | • Ensure sufficiency, security, reliability, quality and cost-effectiveness of energy supply.<br>• Improve productivity/efficiency of energy suppliers and promote a market-based approach in determining energy prices.<br>• Reduce over-dependence on petroleum products through increased use of alternative fuels.<br>• Promote greater use of renewable energy for power generation and industries.<br>• Intensify energy-efficiency initiatives in the industrial, transport and commercial sectors as well as in government buildings.<br>• Expand rural electricity coverage, especially in Sabah and Sarawak.<br>• Develop the energy industry as a viable export earner for the country. |

Figure 3.2: Comparison of Energy-Related Strategic Thrusts

Sources: Economic Planning Unit (EPU), Prime Minister's Department; Corporate Information & Research Unit (CIRU), PETRONAS, 2006

The recently-concluded 9MP clearly required that the energy sector had to emerge as a more robust contributor to the economic development of the country. However, the plan lacked a sufficiently strong emphasis on reducing the negative impact ensuing from the production and utilisation of energy. Generally speaking, all the energy-related thrusts of the plan showed limited fulfilment with the first, fifth and sixth outdoing the others minimally.

Figure 3.3 provides a more fuel-specific comparison of the two plans.

| Fuel | 8th Malaysia Plan | 9th Malaysia Plan |
|---|---|---|
| Oil | • Intensify research in oil recovery and cost reduction.<br>• Develop potential small fields.<br>• Enhance production from mature fields.<br>• Initiate exploration activities in deepwater areas.<br>• Acquire state-of-the-art technology in exploration and production. | • Continue exploration activities in deepwater areas and in small oilfields, especially in Sabah and Sarawak.<br>• Attract further participation of international oil companies in deepwater and ultra-deepwater exploration.<br>• PETRONAS to continue reviewing its international upstream and downstream operations to secure more reserves and increase production from offshore investments. |
| Natural Gas | • Develop domestic resources.<br>• Secure existing gas supply and import LNG from PETRONAS-owned overseas ventures.<br>• Promote utilisation of gas in the commercial and transport sectors.<br>• Produce feedstock for the petrochemical industry and derivatives for local industries. | • Intensify development of domestic resources and secure overseas resources to sustain long-term supply of natural gas.<br>• Expand the existing gas reticulation network by nearly 50% (or 640 km) to support a distribution volume of about 270 million standard cubic feet per day.<br>• Construct an additional 54 NGV fuel stations.<br>• Review further incentives to encourage conversion of standard vehicles into NGVs.<br>• Increase gas imports to comprise 20% of total gas supply by end 2010. |
| Electricity | • Ensure the availability of a sufficient, secure, quality | • Reduce reserve margin to 20% by deferring |

| Fuel | 8th Malaysia Plan | 9th Malaysia Plan |
|---|---|---|
| | and reliable supply of electricity.<br>• Improve the nationwide transmission and distribution network.<br>• Enhance rural electrification programmes.<br>• Restructure the electricity supply industry. | implementation of greater power-generation capacity in Peninsular Malaysia.<br>• Re-consider other previously shelved resources, especially hydroelectric schemes, for power generation.<br>• Implement a pilot waste-to-energy project in Peninsular Malaysia.<br>• Extend the concept of demand risk-sharing and review existing fuel-pass-through arrangements in new power-purchase agreements.<br>• Unify the East and West electricity grids in Sabah and explore the possibility of a Peninsular Malaysia-Sumatra Interconnection Grid.<br>• Intensify rural electrification using solar hybrid and micro-hydroelectric schemes.<br>• Extend the official planning horizon to 15 years to facilitate long-term planning. |
| **Renewable Energy (RE)** | • Intensify the utilisation of RE as the fifth fuel.<br>• Encourage the use of biomass-based co-generation systems for connection to the National Grid. | • Achieve 300 MW and 50 MW grid-connected RE capacities in Peninsular Malaysia and Sabah, respectively.<br>• Improve conditions for the implementation of small RE power projects.<br>• Develop and use solar, |

| Fuel | 8th Malaysia Plan | 9th Malaysia Plan |
|---|---|---|
| | | hydrogen and fuel cells.<br>• Promote the use of a 5% palm oil-diesel blend and undertake efforts to promote its export.<br>• Coordinate R&D activities and enhance local capabilities in RE-based technologies. |

Figure 3.3: Fuel-based Comparison of Strategic Thrusts

Sources: EPU and CIRU

Clear progress has been registered in the oil and natural gas sub-sectors, as well as in the generation of electricity in Peninsular Malaysia. However, the enhancement of the position of RE in the national fuel mix has seen minimal movement.

The 9MP clearly established our *National Mission* as the focusing of the country's efforts towards the realization of Vision 2020. Underlying the plan were a number of strategic thrusts aimed at building a 'smarter' Malaysian economy that would compete on the international stage not just on costs alone but on quality. Compared to its predecessor, the 9MP has seen greater fulfilment since it

- has been more selective on infrastructure spending, in particular, the upgrading of regional airports, the expansion of KLIA and the improvement of the public transport network;
- has placed greater emphasis on education, the upgrading of skills and the raising of the national capacity for knowledge and innovation; and
- has been attempting to address public governance issues more explicitly, especially the implementational capacities of the executing agencies.

The key strategies of the 9MP have included:

- enhancing the competitiveness of Malaysian goods and services;
- raising the efficiency of capital and labour productivity;
- promoting new sources of growth in the agriculture, manufacturing and services sectors of the economy while broadening the contribution of knowledge-based industries to these sectors;

- increasing the contribution of the private sector and GLCs to the process of national development;

- attracting greater foreign direct investment (FDI), especially in hi-tech industries; and

- achieving a more equitable distribution of development around the country by promoting regional growth centres.

The preceding discussion was tantamount to a quick 'walk' through the maze of the big-picture plans. The focus of the reader's attention is now directed towards the country's specific energy-related policies. The good news is that there is no perceivable deficiency in this area.

## The National Petroleum Policy (1975)

This policy was built around five objectives. These were:

- To optimize the use of petroleum resources by providing adequate supplies at reasonable prices;

- To enhance the investment climate and provide opportunities for energy-intensive industries;

- To enhance revenue and export earnings through oil and gas exports;

- To ensure adequate local representation in ownership and management throughout the entire petroleum operation value chain; and

- To encourage the conservation of petroleum resources and environmental protection.

## The National Energy Policy (1979)

Three broad objectives aptly defined this policy. They were:

- The supply objective – to ensure the provision of adequate, secure and cost-effective energy supply through sustainable development of indigenous energy resources, both renewable and non-renewable, using least-cost options and diversification of sources both from within and outside the country;

- The utilization objective – to promote the efficient utilization of energy and the elimination of wasteful patterns of energy consumption; and

- The environmental objective – to minimize the negative impacts on the environment of energy production, transportation, conversion, utilization and consumption.

### The National Depletion Policy (1980)

In 1980, a consensus was reached about the need to prolong the life of our oil and natural gas reserves. Accordingly, a national policy had to be formulated to regulate all daily depletion activities. This policy promptly placed a cap of 600,000 barrels per day on crude oil production. A parallel cap on natural gas set a production limit of 2,000 million standard cubic feet per day for *domestic* consumption purposes.

### The Four-Fuel Diversification Policy (1981)

A disquieting over-dependence on oil during the boom period raised the spectre of an insecure and unreliable long-term supply of this commodity. This policy was aimed at encouraging and enforcing an optimum mix of oil, natural gas, coal and hydropower for the generation of electricity.

### The Five-Fuel Diversification Policy (2001)

This policy, formulated under the 8MP, added renewable energy as the fifth fuel for the generation of electricity. The targeted renewable resources were biomass, solar energy and mini-hydroelectric schemes. The policy was aimed at having 5% of grid-connected electricity derived from renewable resources by 2005.

### The National Green Technology Policy (2009)

This 'new kid on the block' is, to date, the country's most comprehensive all-encompassing policy on energy-related matters. Figure 3.4 summarises its five key objectives, Figure 3.5 its application to four sectors of the national economy, and Figures 3.6, 3.7 and 3.8 its goals in three time-frames covering the present to about 2025 and beyond.

| | |
|---|---|
| 1 | To minimise the growth of energy consumption while enhancing economic development. |
| 2 | To facilitate the growth of the Green Technology industry and enhance its contribution to the national economy. |
| 3 | To increase national capability and capacity for innovation in Green Technology development and enhance Malaysia's competitiveness in Green Technology in the global arena. |
| 4 | To ensure sustainable development and conserve the environment for future generations. |
| 5 | To enhance public education and awareness on Green Technology and encourage its widespread use. |

Figure 3.4: Objectives of the New Green Technology Policy (NGTP)

Source: Ministry of Energy, Green Technology and Water at
http://www.kettha.gov.my/en/content/objectives

| | |
|---|---|
| **ENERGY SECTOR** | **Energy Supply Sub-sector:** Application of Green Technology in power generation and in supply side management, including co-generation by the industrial and commercial sectors.<br>**Energy Utilization Sub-sector:** Application of Green Technology in all energy utilization sectors and in demand side management programmes. |
| **BUILDING SECTOR** | Adoption of Green Technology in the construction, management, maintenance and demolition of buildings. |
| **WATER & WASTE MANAGEMENT SECTOR** | Utilisation of Green Technology in the management and utilization of water resources, waste-water treatment, solid waste and sanitary landfills. |
| **TRANSPORTATION SECTOR** | Incorporation of Green Technology in the transportation infrastructure and vehicles, in particular, bio-fuels and public road transport. |

**Figure 3.5: The NGTP Applied to Four Sectors of the Malaysian Economy**

Source: Ministry of Energy, Green Technology and Water at http://www.kettha.gov.my/en/content/major-sectors

| | |
|---|---|
| 1 | Increased public awareness and commitment for the adoption and application of Green Technology through advocacy programmes. |
| 2 | Widespread availability and recognition of Green Technology in terms of products, appliances, equipment and systems in the local market through standards, rating and labelling programmes. |
| 3 | Increased foreign and domestic direct investments in Green Technology manufacturing and services. |
| 4 | Expansion of local research institutes and institutions of higher learning to enhance research, development and innovation activities on Green Technology towards commercialization through appropriate mechanisms. |

**Figure 3.6: Short-Term Goals of the NGTP – 10MP (2010-2015)**

Source: Ministry of Energy, Green Technology and Water at http://www.kettha.gov.my/en/content/goals

1. Green Technology becomes the preferred choice in procurement of products and services.
2. Green Technology has a larger local market share against other technologies and contributes to the adoption of Green Technology in regional markets.
3. Increased production of local Green Technology products.
4. Increased research, development and innovation of Green Technology by local universities and research institutions and are commercialised in collaboration with local industries and multi-national companies.
5. Expansion of local SMEs and SMIs on Green Technology into the global market.
6. Expansion of Green Technology applications to most economic sectors.

Figure 3.7: Medium-Term Goals of the NGTP – 11MP (2015-2020)

Source: Ministry of Energy, Green Technology and Water at
http://www.kettha.gov.my/en/content/goals

1. Inculcation of Green Technology in Malaysian culture.
2. Widespread adoption of Green Technology to reduce overall resource consumption while sustaining national economic growth.
3. Significant reduction in national energy consumption.
4. Improvement of Malaysia's ranking in environmental ratings.
5. Malaysia becomes a major producer of Green Technology in the global market.
6. Expansion of international collaboration between local universities and research institutions with Green Technology industries worldwide.

Figure 3.8: Long-Term Goals of the NGTP – 12MP (2020-2025) and Beyond

Source: Ministry of Energy, Green Technology and Water at http://www.kettha.gov.my/en/content/goals

As the reader progresses through this report on the energy sector of the Malaysian economy, it will become increasingly clear that this new policy is just what is needed for the nation. The National Green Technology Policy goes a long way toward removing the limitations, redundancies and inconsistencies of all its predecessors. It would appear that those who drafted the document took a long and hard look at everything that came before it?

# CHAPTER FOUR

# The Energy Supply-and-Demand Chain

## GENERAL CONSIDERATIONS

Anyone who has taken more than a cursory glance at energy – What is it? Where do we get it from? How long will it last? – knows that concerns about this vital commodity loom over the horizon of national development. Our future as a nation is rife with hopes and fears, and the energy question hangs about like the clouds, their silver linings circling an ominous darkness. A situational analysis of the energy sector of the Malaysian economy is hence a good place to get started for anyone interested in a deeper discussion about our energy future. This chapter will examine the *status quo* of what the industry experts often call *the energy supply-and-demand chain.*

### The National Energy Policy (1979)

The reader will recall that the three principal objectives of this policy were defined in the previous chapter. These objectives are now discussed in full insofar as they apply to the current energy supply-and-demand chain that exists in the country.

A careful scrutiny of the *supply objective* of the policy will reveal *two clear sub-objectives*, namely, ensuring a continuous and adequate supply of energy for the needs of the country and diversifying our sources to avoid over-dependence on one commodity.

The *first* of these sub-objectives gave birth in 1980 to the National Depletion Policy (which was also outlined in the previous chapter). At that time, crude oil had become the life-blood of the Malaysian economy so extending the lifespan of our oil reserves was the naturally prudent thing to do. In the petroleum industry, the size of an oilfield is measured in terms of how much oil the experts estimate to be present in the ground *in that locality* at the time production starts. The unit of measurement is millions of barrels of *oil initially in place* (OIIP). A major oilfield is one with more than 400 million barrels of OIIP. The policy first restricted annual production from such fields to 1.75% of OIIP. By 1985, this figure had to be relaxed to 3.00% in order to meet increasing demand. With total national production under this restriction running at about 600,000 barrels per day and Malaysia's *proven* reserves standing at about 4,000 million barrels, the nation's supplies are expected to run out by 2025. Hopefully, there is more oil down there than what is currently known to exist and PETRONAS has continued to explore in more areas, including the marginal fields, in Malaysia to ascertain further reserves. However, the country must contemplate its post-2025 oil scenario with immediate effect.

As with oil, the two policies in question had to be applied to our natural gas resources in order to optimize them. Consequently, an upper limit of 2,000 million standard cubic feet per day was imposed for Peninsular Malaysia.

The *second* sub-objective regarding *supply* required diversification away from an over-dependence on oil. So from a *national fuel mix*[1] comprising four commodities in 1981, the strategy shifted to a five-fuel mix in 2001, effectively committing the nation to the aggressive development of renewable energy. The understanding was that as far as was practicable, locally-derived renewable resources would be used to enhance security of supply.

The government's approach towards fulfilling the *utilization* objective of the National Energy Policy has hitherto been to rely on the energy industry and consumers through the implementation of *awareness programmes*. These programmes have been designed to impart some common wisdom on how to exercise efficiency in the production, transportation, conversion, utilization and consumption of energy. The government is conscious of how crucial it is to work with the industrial sub-sector, in particular, in order to raise the efficiency of various processes and reduce wasteful practices. One such programme in this direction is the UN-backed Malaysian Industrial Energy Efficiency Improvement Project (MIEEIP) [2] which was developed to remove barriers to the efficient use of energy in industrial activities. A specific aim of the project was to work towards seeing greenhouse gas emissions in the industrial sub-sector fall by 10% during the period 1999 to 2004.

The following questions with respect to the *utilization* objective of the National Energy Policy still remain:

- Is energy being efficiently utilized in the country?
- If not, what is being done to correct this situation?
- Are wasteful patterns of energy consumption – certainly the status quo! – being systematically eliminated?

Hopefully, these questions will be answered in some measure as the reader progresses through this Report.

The fulfillment of the *environmental* objective of the National Energy Policy is not something that will happen overnight. It is noteworthy that the government has been making all the right moves in the right direction and thus demonstrating its commitment to the concept of sustainable development. It can be expected that in due course, Malaysia will enjoy recognition as one of the environmentally-conscious nations of the world.

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[1] The national fuel mix of a country refers to all the fuels that the energy sector of the country's economy depends upon.

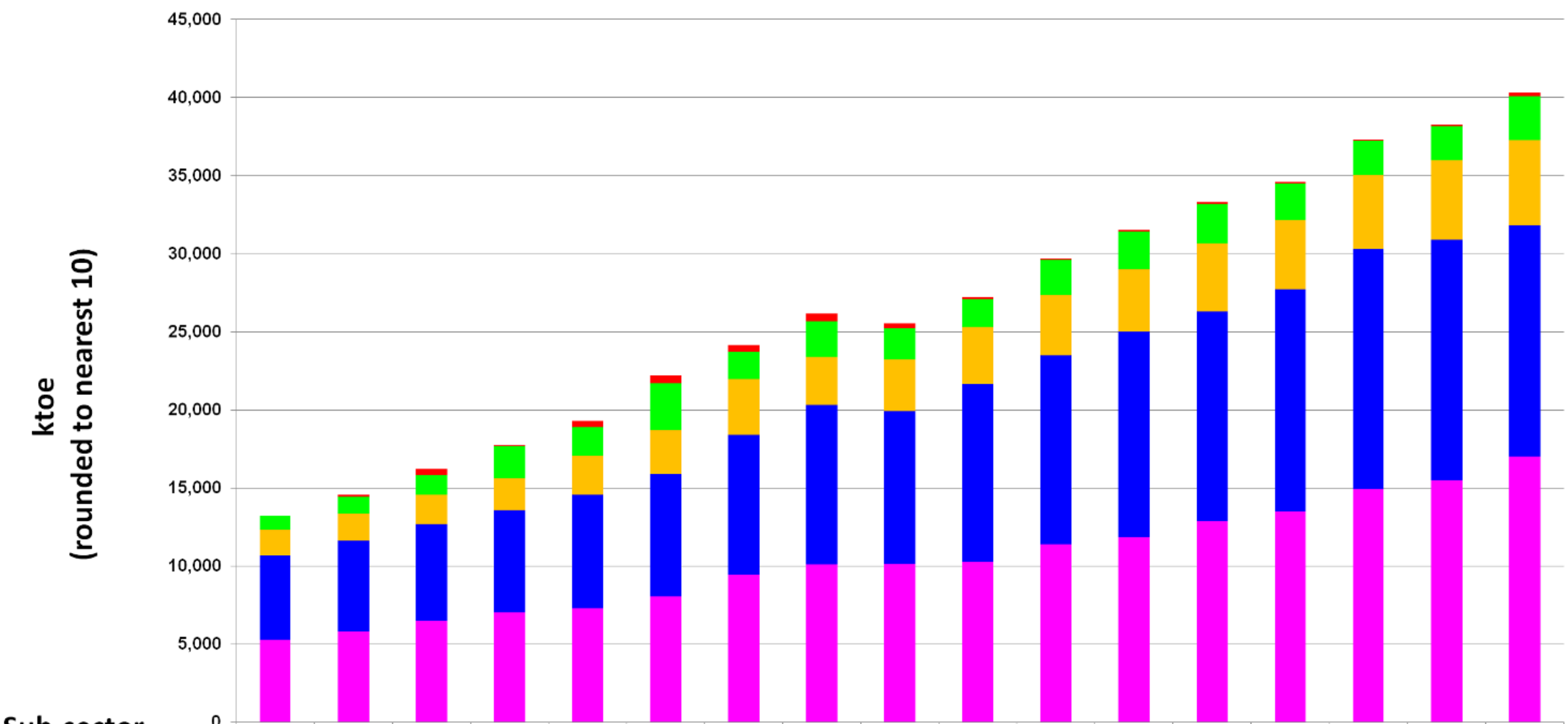
[2] This project was launched in 1999.

## An Overview of the Energy Demand Situation

Figure 4.1 shows how the various sub-sectors that make up the energy sector of the national economy consumed energy over the period 1990 to 2006. The numbers are expressed in *ktoe*[3]. As would have been expected with any developing country, each sub-sector indicated a definite upward trend in demand (i.e. consumption) during the 17-year period. A simple calculation based on the 2006 figures (see the last column) gives the percentage consumption for each sub-sector, as follows:

- industrial – 42% (17,000 ktoe)
- transport – 37% (14,830 ktoe)
- residential & commercial (buildings) – 13% (5,430 ktoe)

[3] Kilotons of oil equivalent




| Sub-sector | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture | 0 | 130 | 390 | 60 | 420 | 450 | 470 | 490 | 310 | 110 | 100 | 100 | 100 | 100 | 90 | 100 | 250 |
| Non-energy | 910 | 1,070 | 1,220 | 2,030 | 1,820 | 2,990 | 1,740 | 2,300 | 2,020 | 1,800 | 2,250 | 2,380 | 2,510 | 2,350 | 2,180 | 2,170 | 2,810 |
| Residential & Commercial | 1,650 | 1,750 | 1,890 | 2,070 | 2,510 | 2,840 | 3,560 | 3,070 | 3,310 | 3,650 | 3,870 | 4,050 | 4,390 | 4,400 | 4,750 | 5,130 | 5,430 |
| Transport | 5,390 | 5,810 | 6,230 | 6,560 | 7,260 | 7,830 | 8,950 | 10,200 | 9,790 | 11,390 | 12,070 | 13,140 | 13,440 | 14,270 | 15,390 | 15,380 | 14,830 |
| Industrial | 5,280 | 5,810 | 6,460 | 7,010 | 7,290 | 8,060 | 9,440 | 10,110 | 10,120 | 10,280 | 11,410 | 11,850 | 12,850 | 13,470 | 14,910 | 15,490 | 17,000 |

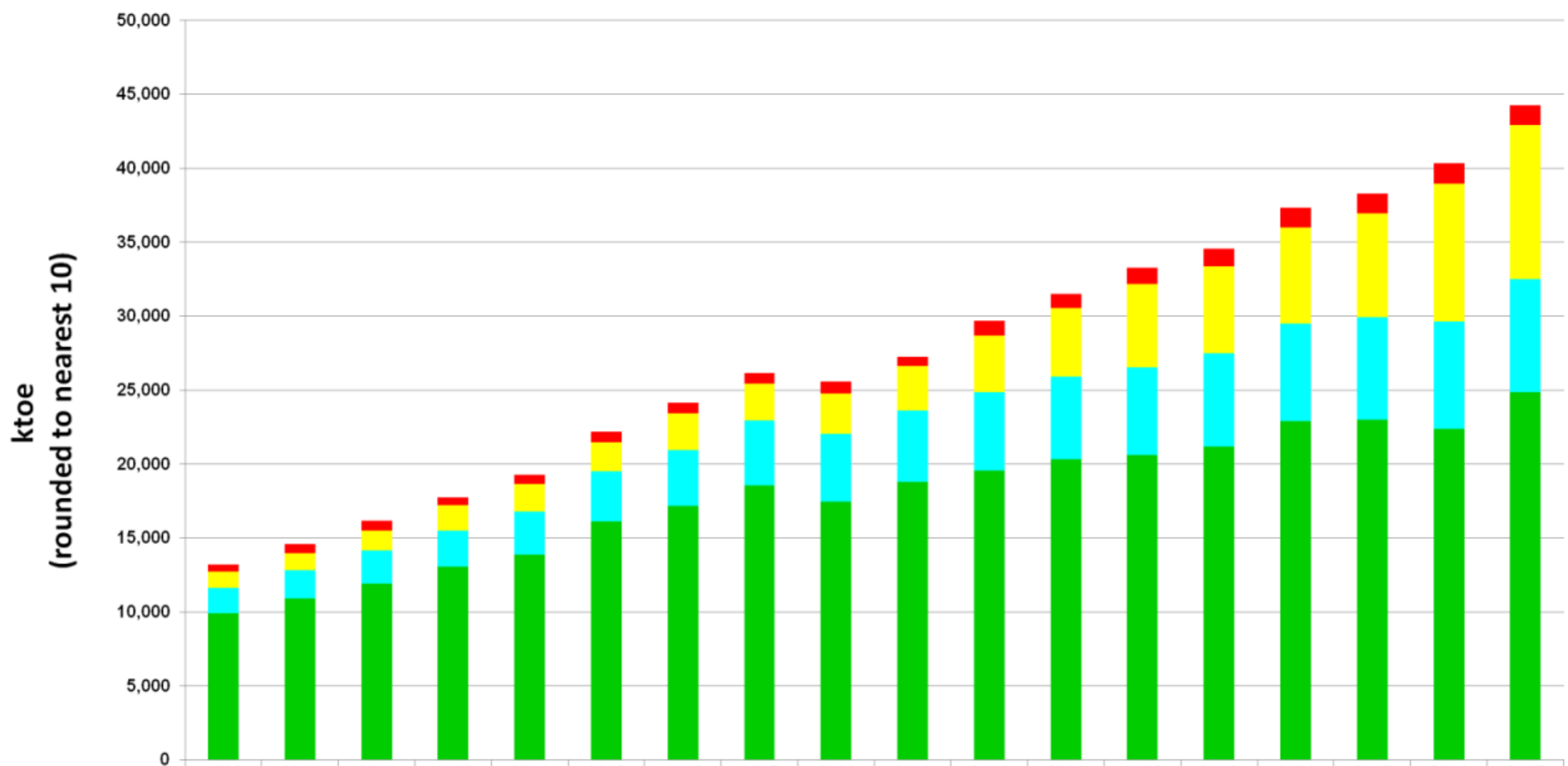
Figure 4.1: Energy Demand by Sub-Sectors

Source: "National Energy Balance 2006", Pusat Tenaga Malaysia (PTM)

Clearly, the industrial and transport sub-sectors together account for nearly 80% of the country's energy demand. It follows that any discussion on energy usage needs to focus on these sub-sectors if it is to be valid. The effect of the lowly 13% figure for the buildings sub-sector is not to be underestimated. While any increase in the usage of energy in the industrial sub-sector will be closely linked with better returns, the buildings sub-sector offers no such linkage. It is thus imperative that we spare no effort to reduce the usage of energy in all our buildings.

Figure 4.2 shows how the national appetite for energy was met by the various sources from which it was derived during the 18-year period from 1990 to 2007. The last column reveals that *the generation of electricity alone* demanded 7,680 ktoe against a total of 44,320 ktoe in 2007. This means that 17.4% of the nation's energy supply was committed to generating electrical energy during that year. The bulk of this electricity was produced for industrial, commercial and residential use. The following breakdown (for which raw supporting data is unavailable) shows how *electrical* energy usage can be attributed to the three major sub-sectors.

- Industrial – 45%
- Commercial – 30%
- Residential – 18%




| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Coal and Coke | 510 | 600 | 670 | 490 | 600 | 710 | 730 | 740 | 770 | 610 | 990 | 980 | 1,090 | 1,210 | 1,310 | 1,350 | 1,340 | 1,360 |
| Natural Gas | 1,090 | 1,130 | 1,370 | 1,720 | 1,860 | 1,940 | 2,470 | 2,470 | 2,730 | 3,020 | 3,860 | 4,620 | 5,640 | 5,890 | 6,490 | 6,980 | 9,320 | 10,370 |
| Electricity | 1,720 | 1,930 | 2,220 | 2,450 | 2,930 | 3,380 | 3,780 | 4,380 | 4,580 | 4,820 | 5,260 | 5,590 | 5,920 | 6,310 | 6,640 | 6,940 | 7,270 | 7,680 |
| Petroleum Products | 9,900 | 10,910 | 11,920 | 13,070 | 13,860 | 16,140 | 17,180 | 18,570 | 17,480 | 18,780 | 19,580 | 20,320 | 20,630 | 21,170 | 22,880 | 23,010 | 22,390 | 24,850 |

Figure 4.2: Energy Supply according to Source

Sources: Power Utilities, Oil Companies & Independent Power Producers; Cement, Iron & Steel Manufacturers

Naturally, the industrial sub-sector with its 45% share of total electricity demand was the first area in which PTM [4] sought a rise in EE (energy efficiency). To date, substantial efforts have been made through various programmes to show industrialists how EE can be raised in their various processes. (The MIEEIP cited earlier in this chapter represents one of these many efforts.) SMEs have been a special target of such endeavours and more programmes are in the pipeline. Full documentation of these can be found in the PTM library. Meanwhile, for this sub-sector, a number of concerns remain.

- More aggressive measures are needed to improve the effective use of energy.
- The recently-enacted regulations on the *Electrical Energy Manager* [5] scheme will need to be enforced to yield results within the next 5 years.
- The government's policy of attracting the correct mix of industry investment will dictate energy usage in the foreseeable future.
- Inherent complexities continue to render this a very difficult sub-sector to address.

Commercial buildings, with their 30% share of total electricity demand, must also be a target for EE measures. Some considerations in conjunction with these measures follow.

- The GBI rating system[6] is now in place for both residential and non-residential buildings. This is unlike MS 1525 [7] which is applicable to non-residential buildings only. It is estimated that primary compliance with the system will realize a 20% reduction in energy usage while full compliance will bring a laudable 60%.
- It is heartening to note that the government has taken ownership of the GBI system. In the October 2009 Budget, very significant tax credit incentives were announced for new and existing buildings achieving GBI certification.
- For commercial buildings, the BEI [8] remains unacceptably high. This warrants immediate action.
- PTM and the international governing authority for GBI differ somewhat in their definitions of the parameters determining BEI. (They also differ on the name given to the quantity, with PTM preferring "Building Energy *Index"*.) There is a need to synchronize these definitions in terms of operating hours, what constitutes floor area, and vacancy factors. There is also an absence of comprehensive data. However, based on the limited data available, PTM has managed to create the graph depicted in Figure 4.3.

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[4] Pusat Tenaga Malaysia, now the Malaysia Green Technology Corporation

[5] An innovative scheme, with the Energy Commission as overseer, in which major users of electrical energy are rated according to how efficiently they utilize electricity.

[6] This is a 'green rating tool' used by the building industry to promote sustainability in the way buildings are designed.

[7] Malaysian Standard 1525: A code of practice, with SIRIM as overseer, on energy efficiency and renewable energy for non-residential buildings.

[8] Building Energy Intensity, measured in kWh per square metre of floor area per year

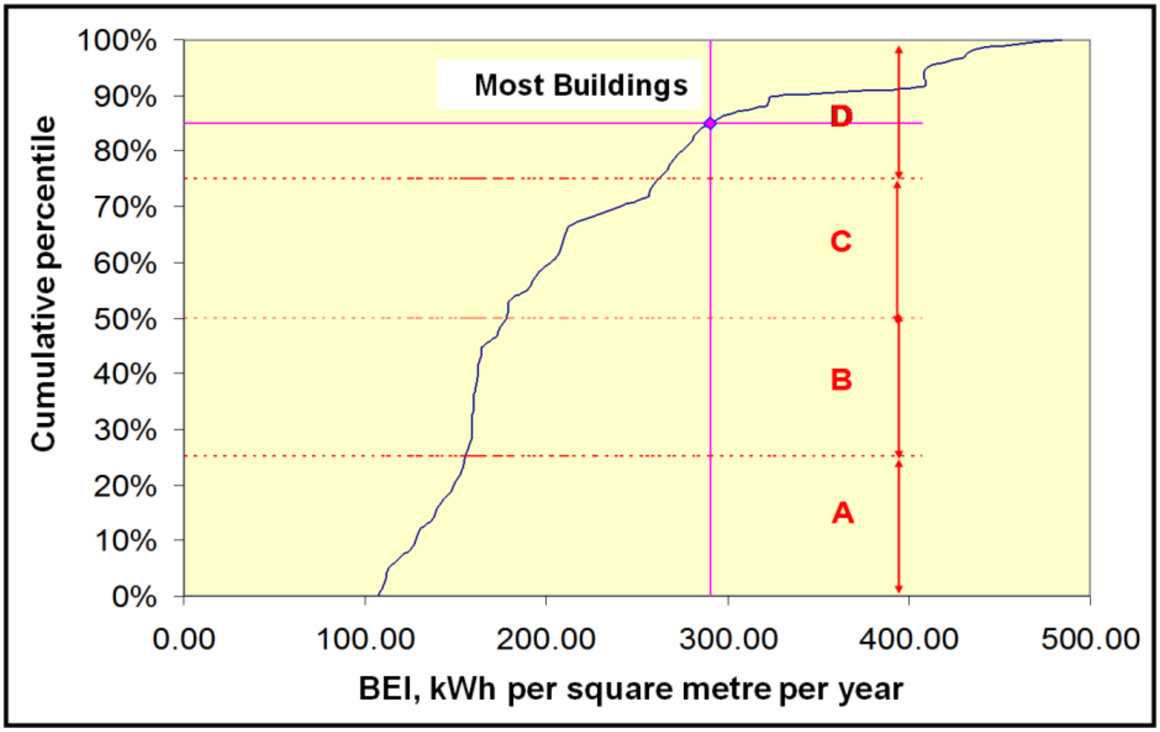


Figure 4.3: Building Energy Intensity/Index

Source: Pusat Tenaga Malaysia

The suggested 60% reduction figure that could be realized through full compliance with the GBI rating system is not an unrealistic target. Developed nations are already formulating long-term strategies to make zero-energy buildings[9] the norm rather than the exception. These strategies are not new ideas but existing applications that have been improved and refined. The recommendations of the study team in this connection are presented in Chapter 9.

[9] A zero-energy building, more aptly named a "zero-energy-consumption building", is one that is totally self-sufficient in energy needs.

# ELECTRICITY

Figure 4.4 shows the *generation mix* (2007 data) for the Malaysian power industry covering the period 1976-2030[10]. A cursory glance at the figure will reveal that in the 1970s, we had a singular dependence on oil. Five decades down the line, in 2020, our fuel mix will see a six-way split.

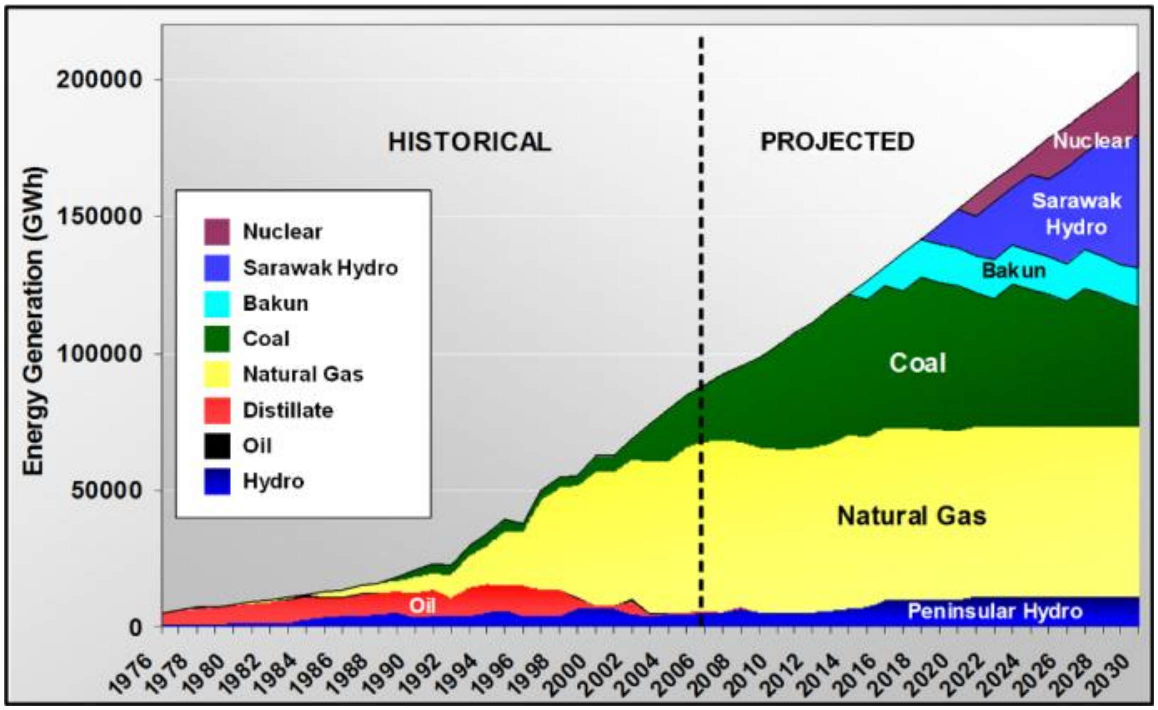


Figure 4.4: The Generation Mix of the Malaysian Power Industry (1976-2030)

Source: Md Sidek Ahmad, Keynote Address, International Seminar on Advances in RE Technologies (ISARET), 2009, sponsored by TNB.

## Electricity Supply Security – Peninsular Malaysia and Sabah

In 2008, the *installed capacity* [11] for Peninsular Malaysia was just short of 20,000 MW while the peak demand was a tad over 14,000 MW[12]. A reserve of 6,000 MW then was

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[10] The term *generation mix* refers to all the forms of fuel on which a country's power stations run.

[11] Installed capacity refers to the cumulative power available if all our power stations are running simultaneously at full capacity.

[12] Source: TNB 2008 Annual Report.

seemingly good news. But Figure 4.5 raises some serious concerns for the near-to-medium term.

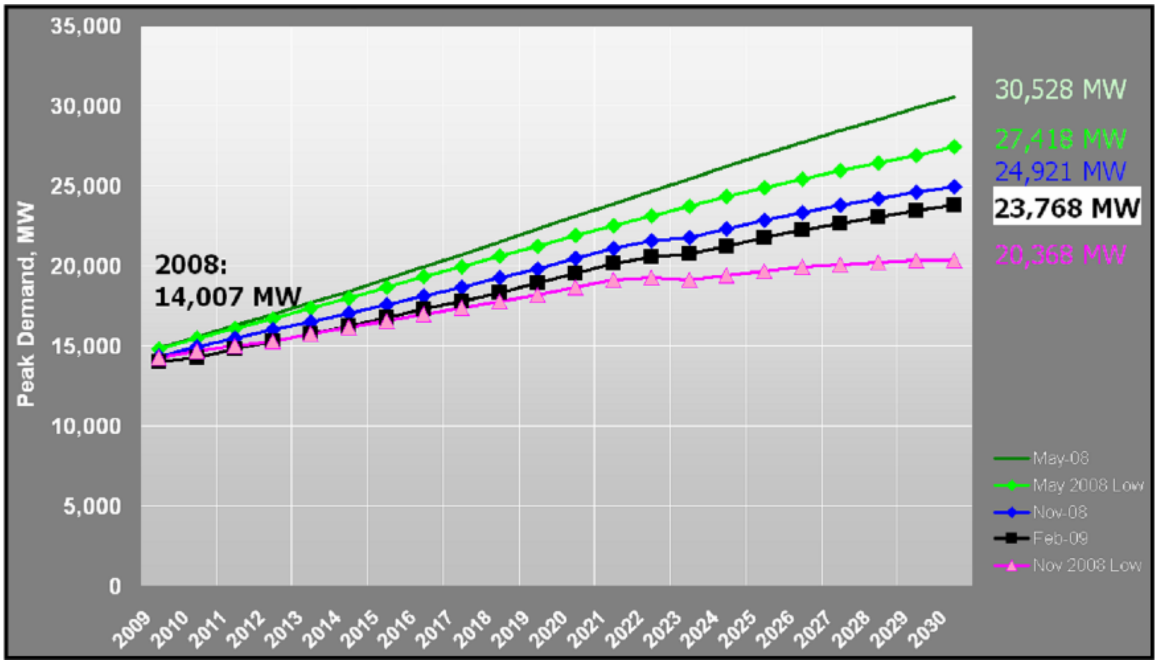


Figure 4.5: Electricity Demand Forecast based on Peak Demand

Source: TNB Roundtable Discussions on Renewable Energy, May 2009

Demand forecast curves like those presented above are mathematically generated to represent various scenarios that could unfold based on a variety of real on-the-ground factors. In the opinion of the country's energy experts, our peak demand is expected to be between 20,000 and 30,000 MW in 2030.

At the plenary session of the 2009 International Energy Week Forum, the Chairman of TNB announced a projected increase in electricity demand of about 500 MW annually for the next few years based on economic growth of 3% per annum. A simple calculation shows that our 6,000 MW reserve would dwindle to nothing in 12 years from 2008. This means that the year by which we hope to achieve that coveted developed-nation status would also be the year by which our current installed capacity runs out. It is clear that some rather urgent planning is needed to confidently carry Peninsular Malaysia beyond 2020.

The impending acute shortage of electricity-generating capacity in the medium term poses a major challenge for the country. The obvious solution is to build more power stations. But this raises the question of how to deal with the generation mix in the face of dwindling fuel supplies.

The generation mix for electrical power generation in Peninsular Malaysia and Sabah for 2008 is shown in Figure 4.6.

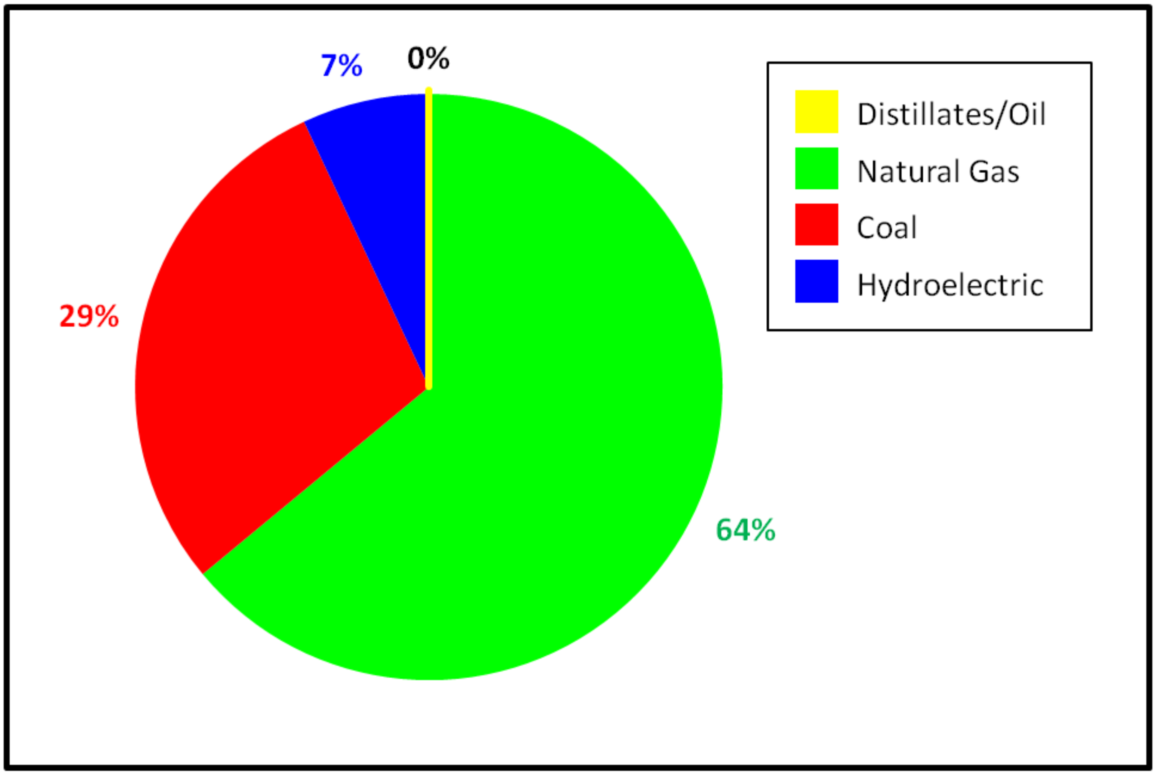

Figure 4.6: Electrical Power Generation Mix for 2008 in Peninsular Malaysia and Sabah

Source: TNB Annual Report 2008. (The 0% figure in the pie-chart above represents an actual value less than 0.5% rounded down to zero.)

The pie-chart makes it readily obvious that natural gas has been the kingpin of our fuel mix for the generation of electricity for some time. Unfortunately, the power sub-sector has been facing limitations on the availability of natural gas. This means that we have to increase our reliance on imported coal. However, the large demand for coal from traditional suppliers by China and India will inevitably put these two industrial giants in competition with us. Hence, *energy supply security has thus become a major challenge for our power generation industry.*

A comprehensive strategy is needed so as not to compromise the security of our energy supply. TNB is working aggressively to identify alternative fuel sources and to further diversify our generation mix. Peninsular Malaysia has a yet untapped hydropower potential of 1700 MW and the development of about one-third of this has already been initiated. The *Sarawak Corridor of Renewable Energy* has the potential to generate a whopping 28,000 MW of electricity but the 800-kilometre nautical divide between East and West Malaysia poses an enormous engineering challenge in terms of transmission. Several other options are also being explored. These include renewable energy sources such as solar and biomass. TNB is also seriously looking at nuclear energy as a viable power source for the generation of electricity in the medium term and beyond. Figure 4.7 shows the *projected* fuel mix for electrical power generation in Peninsular Malaysia for the year 2030.

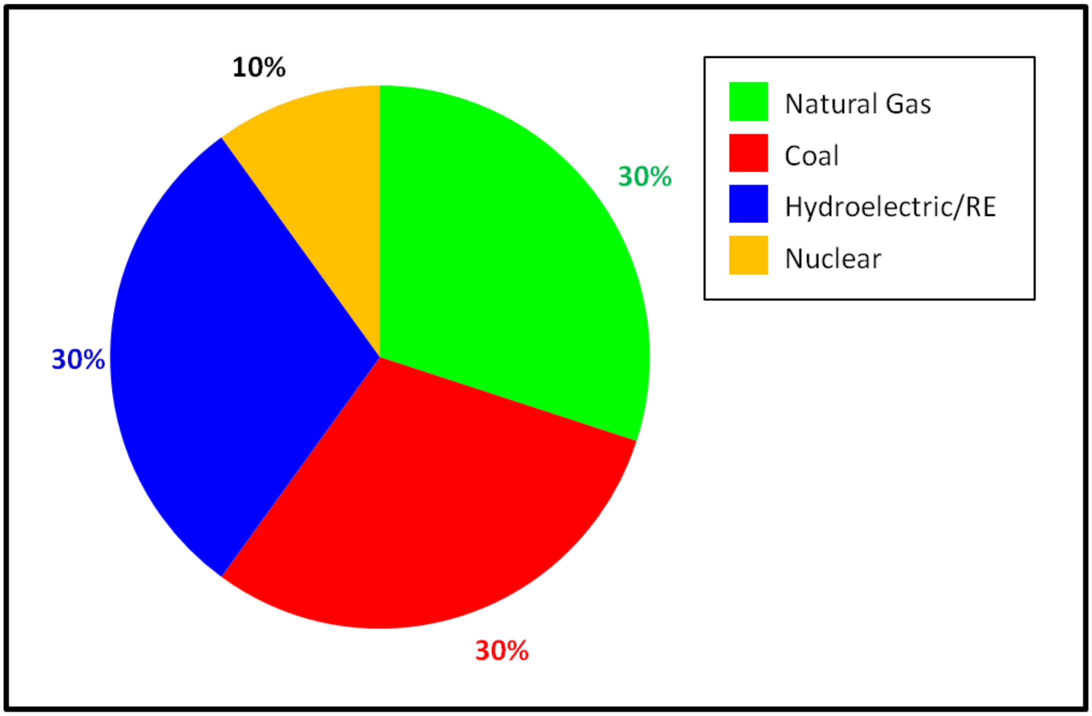


Figure 4.7: Projected Fuel Mix for 2030 in Peninsular Malaysia and Sabah

Source: TNB Annual Report, 2008

## Major Hydroelectric Schemes

As indicated in the previous section, there remains a hydropower potential of about 1,700 MW available from a number of remaining *major* river basins in Peninsular Malaysia. It is envisaged that the power stations located at these sites will be required to feed electricity into the National Grid for only 2-3 hours daily in order to handle peak demand.

Work at two of these sites is already in progress. These are:

- Hulu Terengganu (250 MW), to be commissioned in 2013; and
- Ulu Jelai in Perak (372 MW), to be commissioned in 2014.

Some of the major hydroelectric power schemes are shown in Figure 4.8.

| Name | Location | Installed Capacity |
| --- | --- | --- |
| Bakun Dam | Balui River Basin, Sarawak | 2,400 MW |
| Batang Ai | Batang Ai Natural Park, Sarawak | 100 MW |
| Chenderoh | Tasik Chenderoh, Perak | 40 MW |
| Murum | Murum, Sarawak (under construction) | 944 MW |
| Pergau | Kuala Yong, Kelantan | 600 MW |
| Kenyir Dam | Terengganu | 400 MW |
| Temenggor | Gerik, Perak | 348 MW |
| Tenom Pangi | Padas River, Sabah | 66 MW |

Figure 4.8: Some of the Major Hydroelectric Schemes in Malaysia

It is hoped that in the near future, appropriate financing can be found to

- develop dual-purpose schemes at Lebir and Nenggiri for flood control and power generation; and
- systematically develop the remaining hydropower sites.

## Mini Hydroelectric Schemes

Mini hydroelectric schemes have also been developed in Malaysia (Figure 4.9).

| Description | Capacity (MW) |
|---|---|
| Major hydroelectric schemes that meet the CDM criterion of exceeding 4W per square metre | 988 |
| Batang Padang (Cameron Highlands) | 12 |
| Mini Hydro (Kelantan, Pahang) | 12 |
| Tenom Pangi (Sabah) | 66 |
| Mini Hydro (SESB [13] ) | 8 |
| Total | 1,086 |

Figure 4.9: Total Hydroelectric Capacity as Renewable Energy in Malaysia (as defined by the Kyoto Protocol CDM[14])

Source: TNB

## Electricity Supply Security – Sarawak

Sarawak has a full potential of about 28,000 MW of electrical power. Of this, some 20,000 MW will come from major hydroelectric schemes at Batang Ai, Bakun, Murum, Pelagus, Baleh and Limbang. Besides its vast hydroelectric resources, the country's largest state also has coal reserves of 1,467 million tonnes aggregated from deposits around Mukah, Balingian, Nanga Merit and Limbang in the Central Region. Also in this region and in proximity to Bintulu are vast natural gas reserves amounting to 40.9 trillion standard cubic feet.

The Sarawak Corridor of Renewable Energy (SCORE) is a huge initiative being undertaken to transform Sarawak into a "developed state" by 2020. As one of the five *development corridors* throughout the country, it aims to accelerate the state's economic growth and improve the quality of life of its people. SCORE will address the five key thrusts outlined in the National Mission (2006 – 2020) which aims for the highest level of performance throughout the country and maximum benefit from the various development

13 Sabah Electricity Supply Board.

14 The Kyoto Protocol Clean Development Mechanism

efforts. At the heart of the SCORE concept lie the six development strategies for Sarawak in the Ninth Malaysia Plan. These are: (1) developing human capital and R&D capabilities, (2) speeding up growth in the rural areas, (3) capitalizing upon energy resources, (4) engaging the private sector, (5) enhancing the quality of life, and (6) improving the implementation machinery and delivery system.

The corridor will require a total investment of RM 334 billion to fully develop the state's Central Region and achieve its mission. The electricity sub-sector alone will need RM 67 billion of investment to build the power-generation infrastructure that is vital to the success of SCORE. Figure 4.10 represents the electrical power that the state will demand by 2030 while Figure 4.11 indicates which resources will be used to generate that power.

| | |
|---|---|
| Existing Consumers | 3,000 – 3,500 MW |
| New Projects | 5,000 – 18,000 MW |
| Export to TNB and Neighbours | 4,000 – 6,500 MW |
| Total Demand | 12,000 – 28,000 MW |

Figure 4.10: Power Demand in Sarawak by 2030

Source: SESCO [15]

| **Approximate Time Frame** | **2006** | | **2015** | | **2020** | | **2030 – 2037** | |
|---|---|---|---|---|---|---|---|---|
| Source | Capacity | % Share | Capacity | % Share | Capacity | % Share | Capacity | % Share |
| Hydroelectric Power | 94 | 9.7 | 3,564 | 50.6 | 5,970 | 49.5 | 20,000 | 71.4 |
| Coal | 210 | 21.7 | 3,000 | 42.6 | 5,000 | 41.5 | 5,000 | 17.9 |
| Natural Gas | 481 | 49.8 | 481 | 6.8 | 481 | 4.0 | 481 | 1.7 |
| Diesel | 181 | 18.8 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Renewable Energy | 0 | 0.0 | 0 | 0.0 | 600 | 5.0 | 2,519 | 9.0 |
| Total | 966 | 100.0 | 7,045 | 100.0 | 12,051 | 100.0 | 28,000 | 100.0 |

Figure 4.11: Sarawak Power-Generation Capacity in MW

Source: SESCO

[15] Sarawak Electricity Supply Company

Clearly, the country's largest state has a sufficient energy capacity to meet the demand of local industries, the rest of the country, as well as export.

# OIL & NATURAL GAS

In the oil and gas industry, STI principles and techniques are applied throughout the energy supply-and-demand chain which is made up of four main links, as shown in Figure 4.12. These are primary energy supply (upstream), energy transformation processes (midstream) and secondary energy supply feeding final end-user demand (downstream).

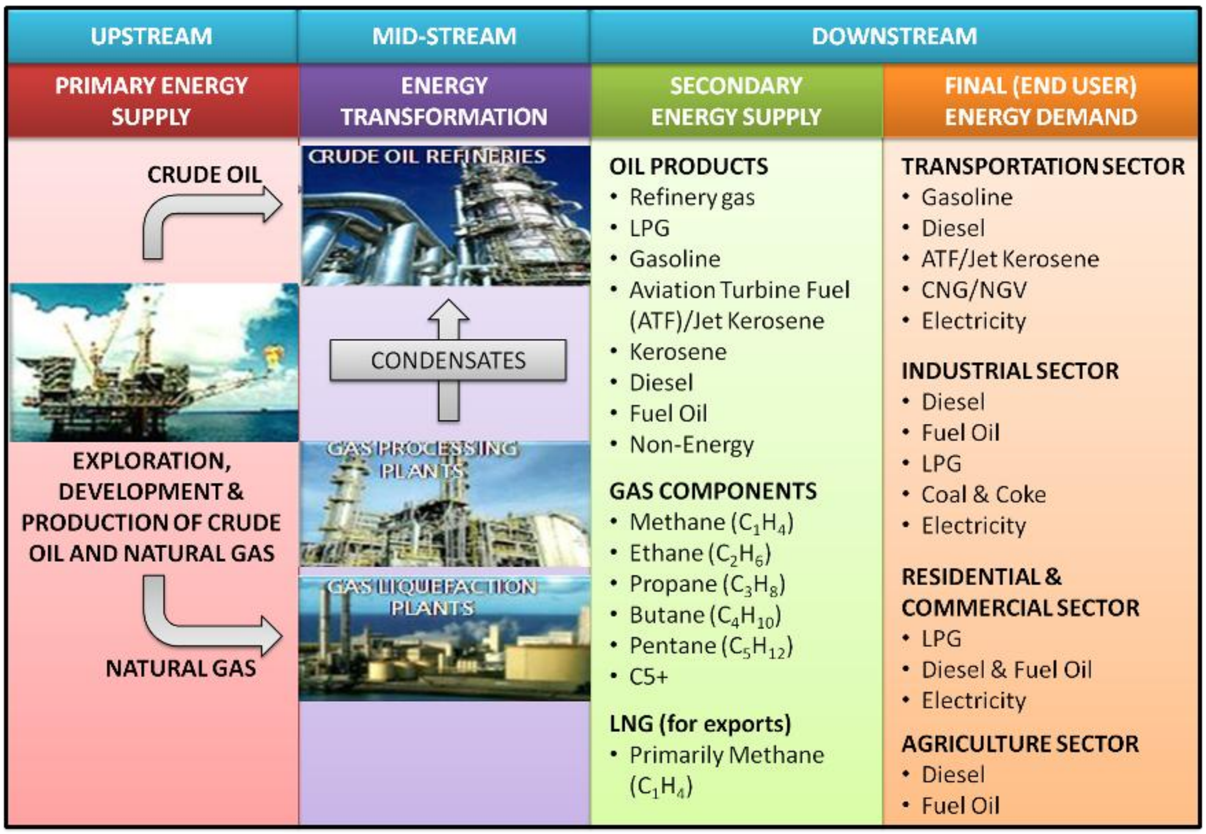


Figure 4.12: The Supply-Demand Chain in the Oil and Gas Industry

Source: Study Team

The upstream segment comprises exploration activities, the identification of commercially viable wells, the building of production platforms and the extraction of indigenous crude oil and natural gas.

The midstream or energy-transformation segment involves the refining of crude oil to yield refinery gas, liquefied petroleum gas (LPG), gasoline, aviation turbine fuel (ATF) or jet kerosene, diesel, fuel oils (for ships, factories and central heating), lubricating oils and 'non-energy' products such as bitumen and tar. Natural gas is a mixture of hydrocarbon-based components which are separated from each other and later re-mixed in desired proportions for various applications. Its components are methane ($CH_4$), ethane ($C_2H_6$), propane ($C_3H_8$), butane ($C_4H_{10}$), pentane ($C_5H_{12}$) and the condensates (which are *alkanes* with six or more carbon atoms per molecule).

Alternatively, natural gas can be cooled to temperatures below -162°C and liquefied by the application of pressure to form LNG (liquefied natural gas). Converting a gas into a liquid makes it more compact thus facilitating storage or transportation over long distances via LNG tankers.

All these processes involve the applications of STI knowledge before the various fuels and substances reach the end-user in the transportation, industrial, residential, commercial, agricultural and non-energy sub-sectors.

## Natural Gas

Figure 4.13 shows that the bulk of the natural gas produced in the country is converted into LNG while just over one-third (35.42%) is used in our power stations and industries (mainly manufacturing). These three areas together account for just about 90% of the total consumption.

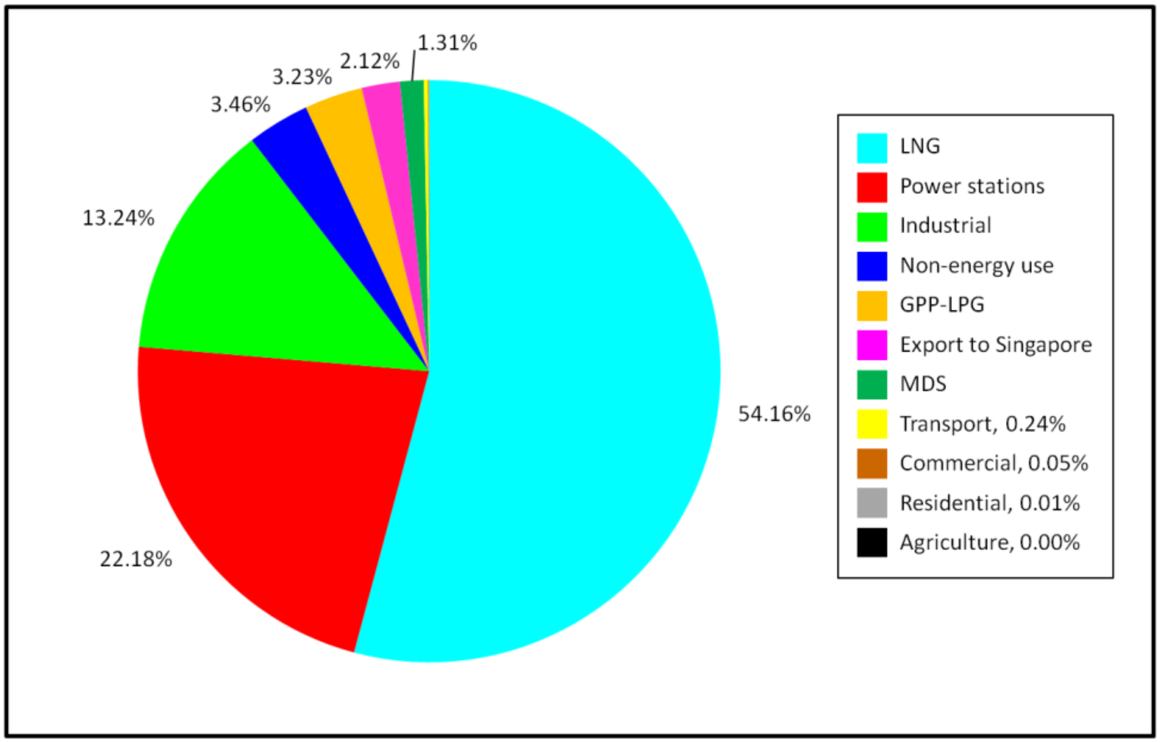


Figure 4.13: Natural Gas Consumption by Sub-Sectors, 2007

Source: NEB 2007

Figure 4.14 suggests that a major problem is in the making on the supply (production) side.

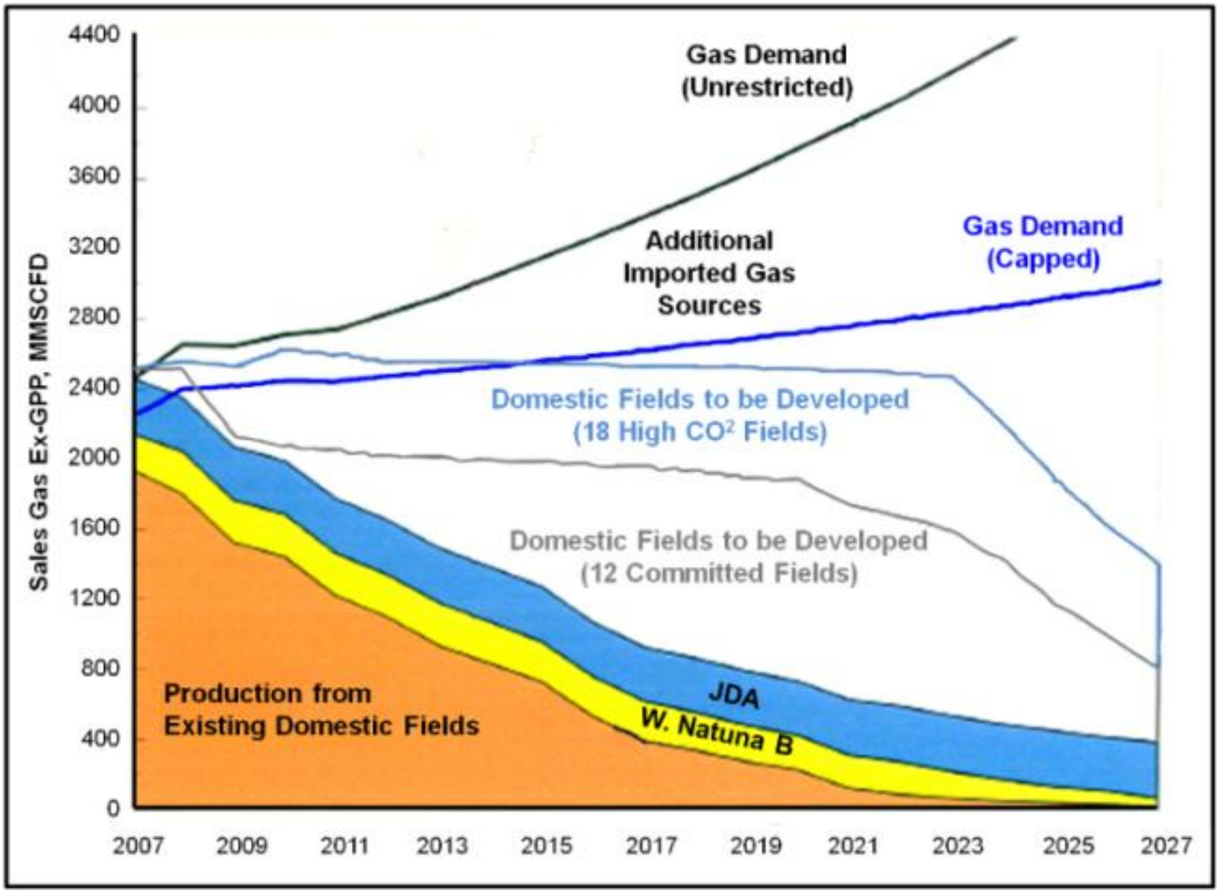


Figure 4.14: Projection on Natural Gas Production and Utilization, 2007-2027

Source: PETRONAS. (Note: (1) W. Natuna B is an Indonesian gas field; JDA refers to gas fields under the Malaysia-Thailand Joint Development Authority. (2) MMSCFD is millions of standard cubic feet per day)

The issues connected with the utilization of natural gas for power generation are as follows:

- The demand currently exceeds the supply.
- Local gas supplies are depleting and are uncertain beyond 2019.
- The non-power sub-sector is clamouring for gas that has already been allocated to the power sub-sector.
- Current gas prices are not reflecting the cost of supply hence there is little or no incentive for investing in new supplies.

Some solutions to the above issues are:

- Develop small and marginal fields.
- Enhance the import of gas from Indonesia and the Malaysia-Thailand JDA.

- Re-consider the current and future gas exports to Singapore.
- Develop a more sustainable basis for allocating gas supplies to the power-generation and non-power sectors.
- Apply leverage on LNG terminals being built by Thailand and Singapore.
- Develop an LNG re-gasification terminal in Peninsular Malaysia.
- Gradually remove all subsidies.

## Crude Oil and Natural Gas Reserves

In early 2008, the country's indigenous *proven* oil reserves stood at 5.46 billion barrels while the figure for natural gas was 88 trillion *standard cubic feet* (scf). One barrel of oil is equivalent in *energy yield terms* to 6,000 scf of gas. Hence our gas reserves can be expressed as 14.67 billion *barrels of oil equivalent* (boe). This places our combined proven oil and gas reserves at 20.13 boe. Figure 4.15 sums up the situation with our reserves.

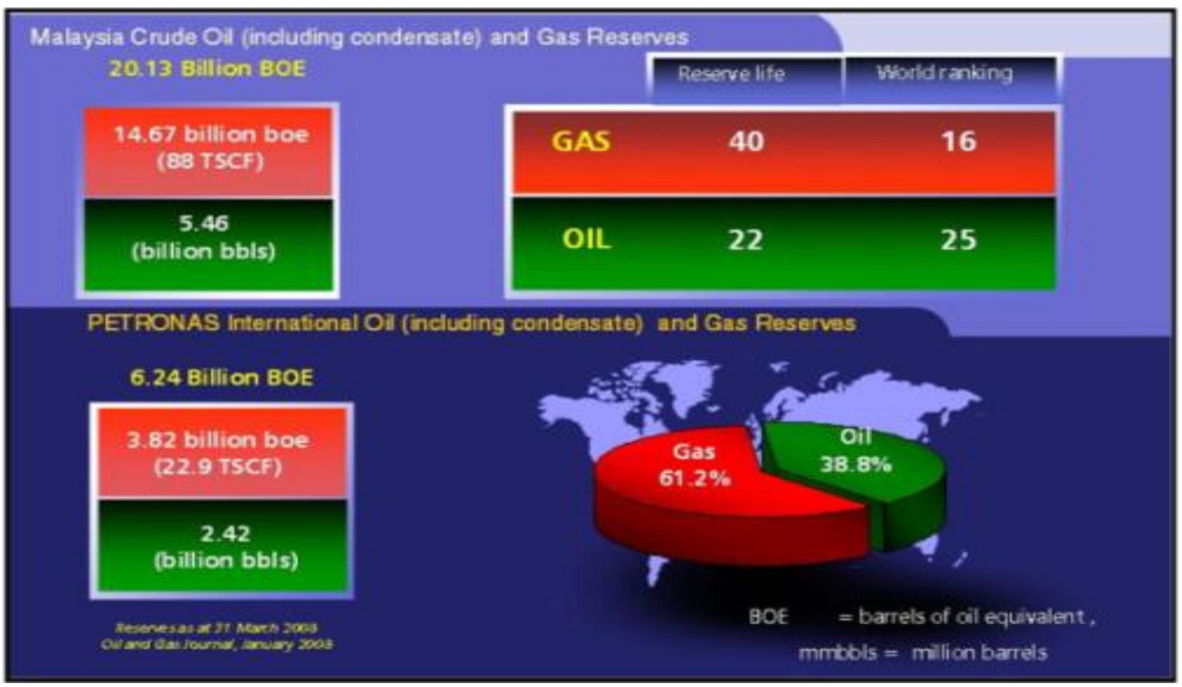


Figure 4.15: Proven Oil and Gas Reserves, March 2008

Source: Corporate Information and Research Unit (CIRU), PETRONAS, 2008

The application of STI in exploration and related activities has resulted in our capacity to 'replenish' what we have extracted thus far such that our *reserve-to-production ratios* [16] stand at about 20 and 40 years for oil and gas, respectively.

Nevertheless, the proven oil and natural gas reserves of the country are relatively small in comparison to those of the big players in the global industry, as Figures 4.16 and 4.17 clearly show. As such, these depletable and valuable national assets have to be utilized prudently in order to enhance the security of energy supply and safeguard the national interest in sustainable development.

[16] The reserve-to-production ratio of a commodity is the estimated time it would take to exhaust known reserves of the commodity at current production or extraction levels.

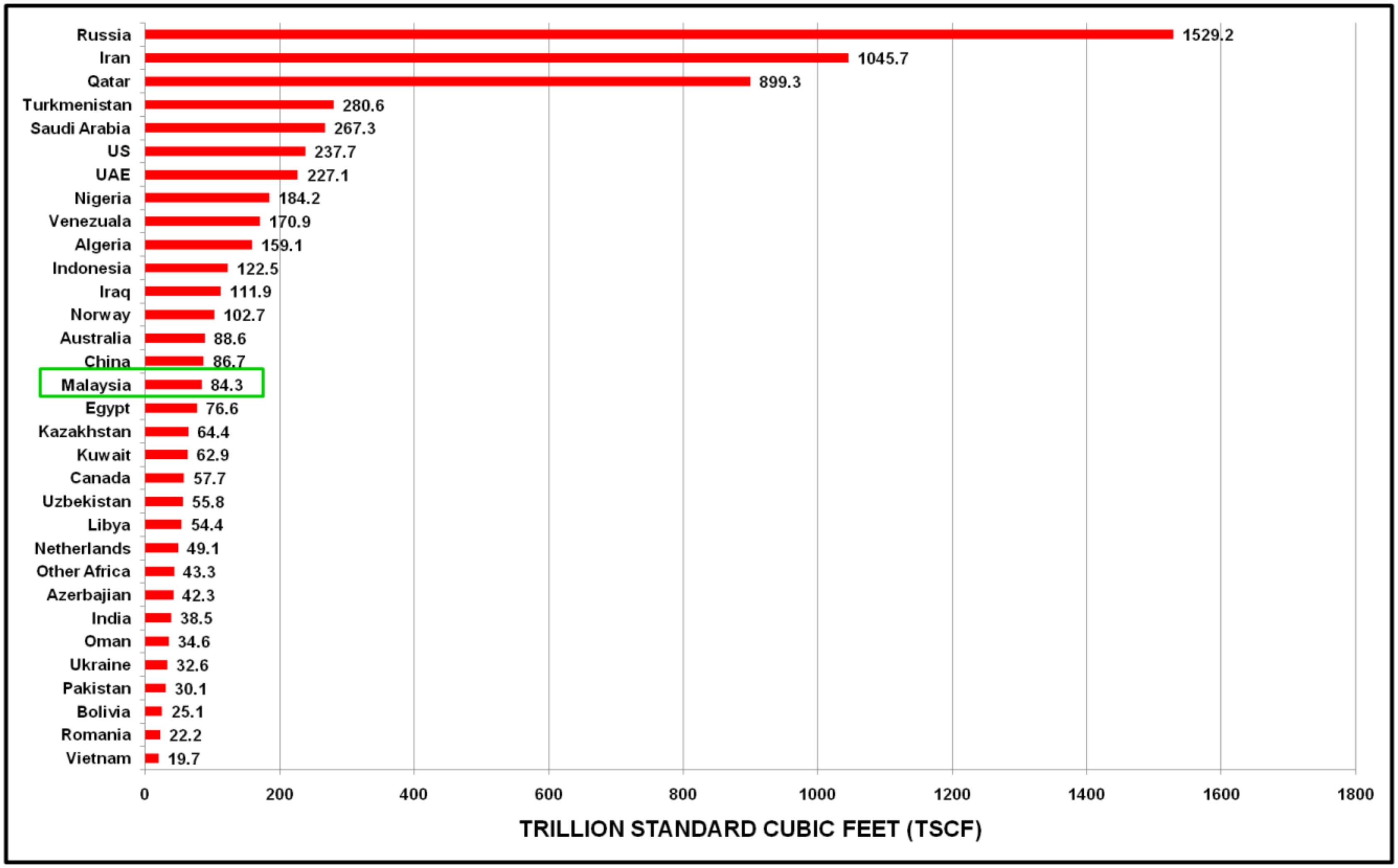


Figure 4.16: Proven Oil Reserves of Malaysia as Compared to Other Oil-Producing Countries

Source: Statistical Review of World Energy, British Petroleum, June 2009

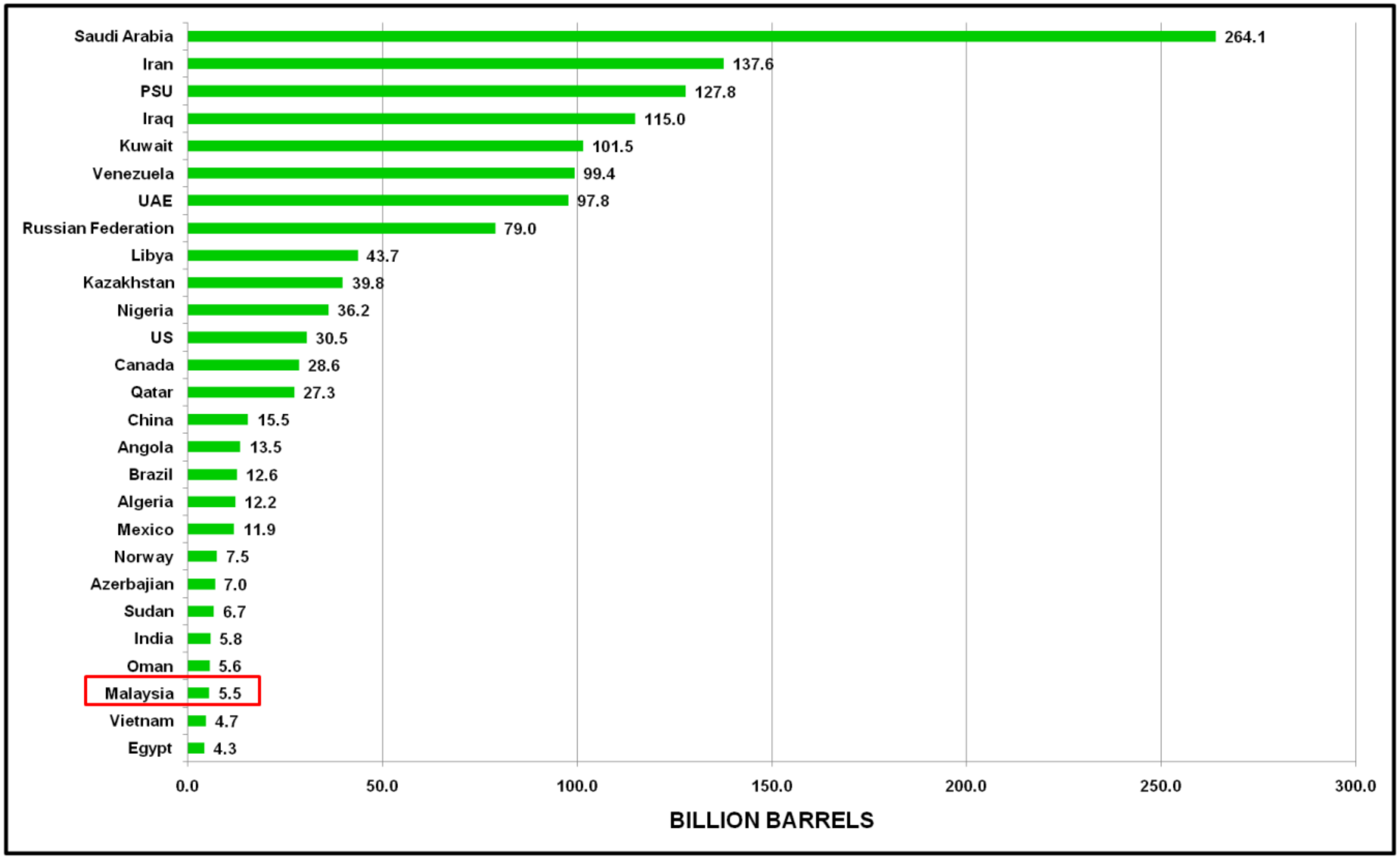


Figure 4.17: Proven Gas Reserves of Malaysia as Compared to Other Gas-Producing Countries

Source: Statistical Review of World Energy, British Petroleum, June 2009

### Oil-Production and Gas-Production Models

Figure 4.18 illustrates a hypothetical oil production-cum-consumption model which has been developed by a member of the study team to conceptualize the scenario the country might face due to declining production levels. Figure 4.19 shows a similar model for natural gas.

Each model is based on our indigenous oil and gas reserves but is hypothetical in that extrapolations are made into the medium and long term for which there is a dearth of good data and information.

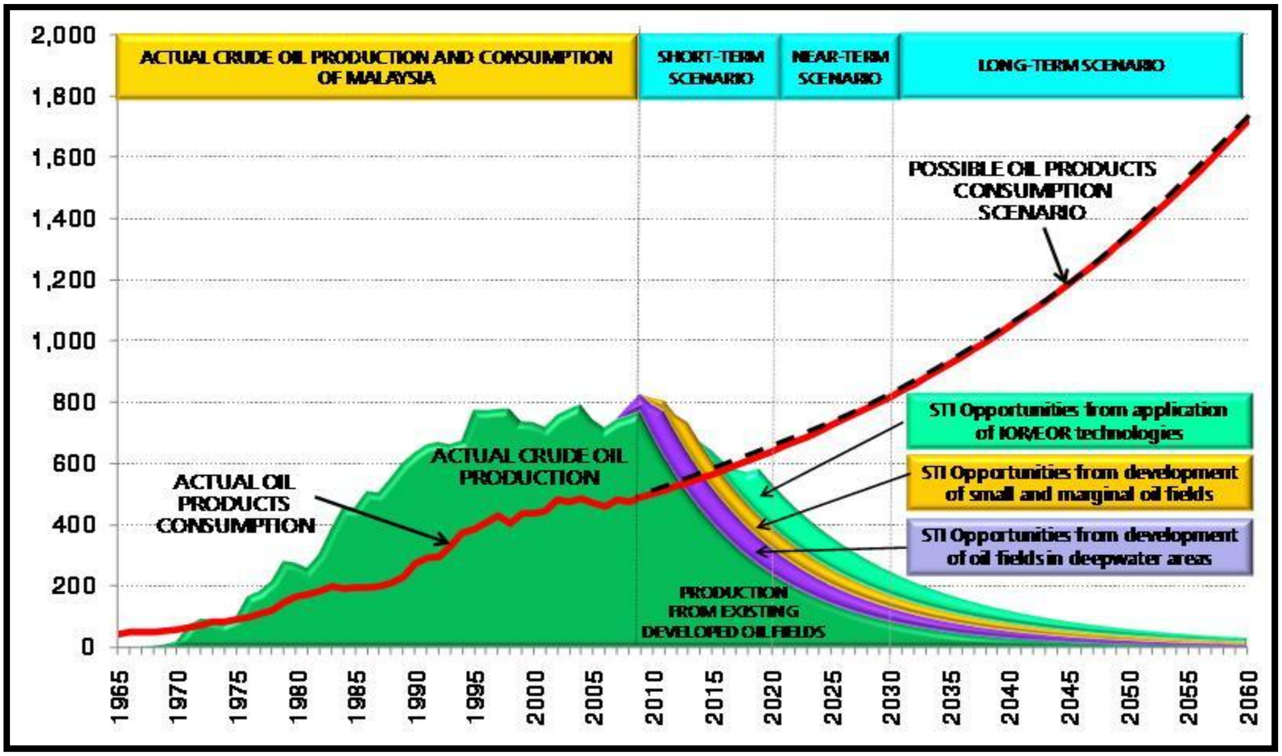


Figure 4.18: A Hypothetical Model of Oil Production vs. Consumption

Source: Study Team

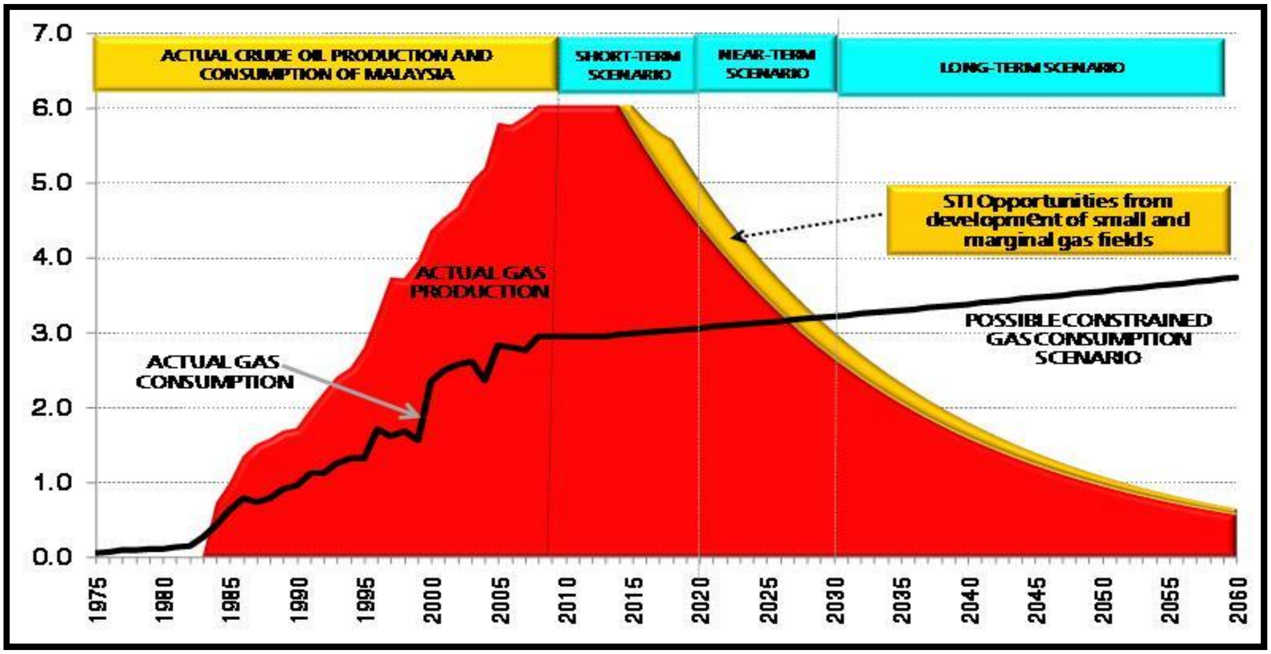


Figure 4.19: A Hypothetical Model of Gas Production vs. Consumption

Source: Study Team

The actual crude oil production levels as shown in Figure 4.18 cover the period 1970 to 2008. Assuming that no new fields are discovered and developed, the production level from existing developed and mature fields would decline rapidly. This scenario could occasion a shift in Malaysia's status from that of net producer to that of net importer as early as 2012.

There are three possible STI-related opportunities in the oil sub-sector to enhance the security of supply and promote sustainability. These are:

- exploration to discover and develop new fields;
- development of small and marginal fields; and
- data review leading to rejuvenation of mature fields.

These opportunities are discussed in greater detail in Chapter 7.

Figure 4.19 clearly shows that the outlook for natural gas is significantly better. Assuming that no new fields are discovered, the possible transition from net producer to net importer status could occur in 2025, if at all. Emerging STI opportunities in the short term should therefore focus on optimizing gas production levels in order to sustain the country's status as a net exporter. These are:

- development of small, marginal and stranded fields; and
- review of field data leading to rejuvenation of previous reservoirs.

These, too, are presented in more detail in Chapter 6.

# COAL

A quick reference back to Figure 4.14 and the accompanying remarks will remind the reader that natural gas supplies are *unreliable* beyond 2019. The planned development of 12 "committed" and 18 "high $CO_2$" fields can potentially make up for the expected shortfall but there are no guarantees. One possible emerging scenario is greater dependence on coal for the generation of electrical power. Figure 4.20 shows that if all goes well on the gas front, annual demand for coal will level off at 20 million tonnes. But failure to develop the 30 gas fields referred to earlier might occasion a 100% rise in coal demand to 40 million tonnes just beyond 2019. Figure 4.21 dramatically illustrates how volatile coal prices had been in the June 2006 to February 2009 time-frame. Similar volatility in any future time-frame is to be expected and does not augur well for any economy that depends too heavily on coal for electrical power.

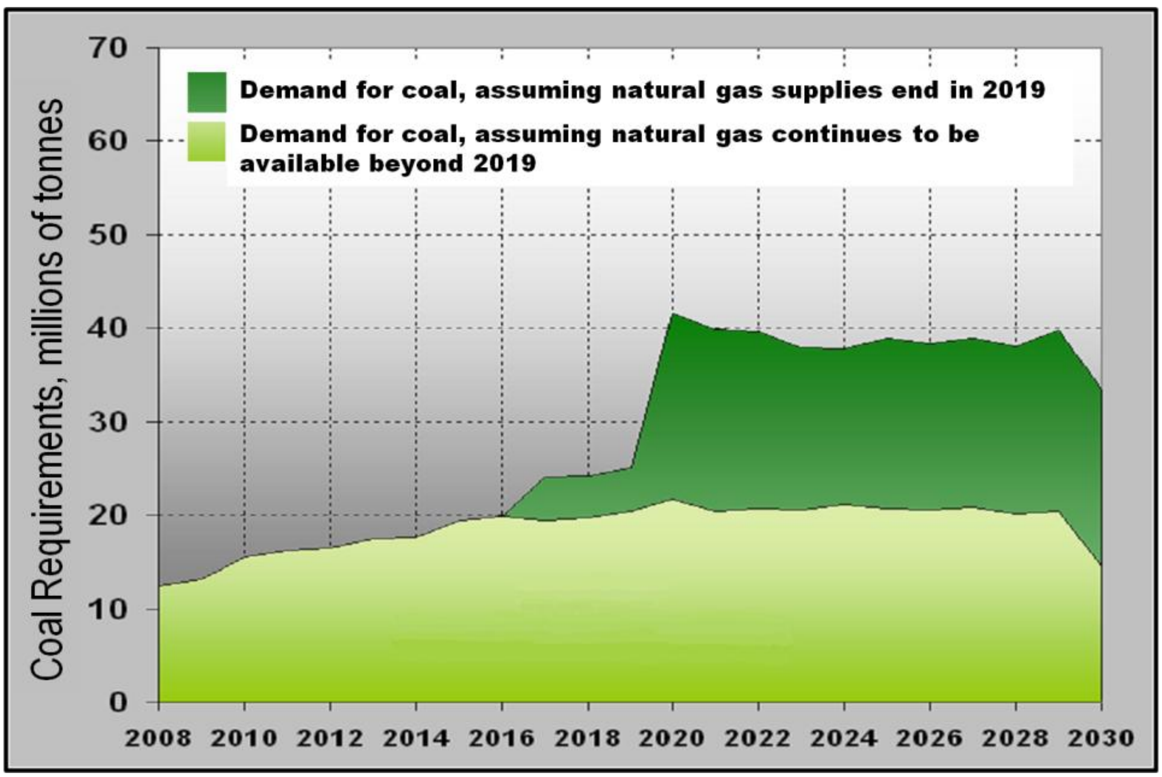


Figure 4.20: Projected Coal Requirements for Power Generation, 2008-2030

Source: TNB

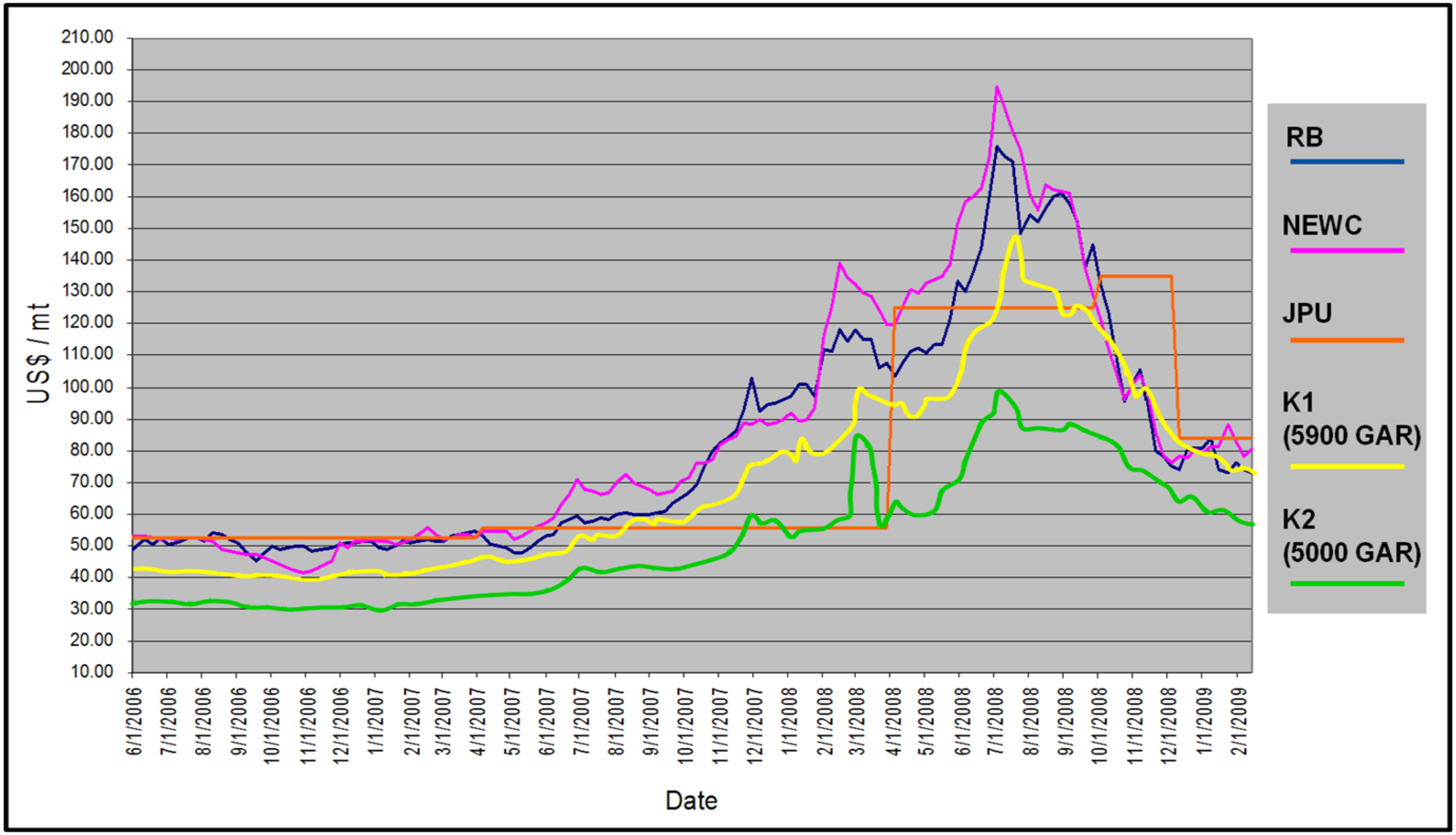


Figure 4.21: Volatility of Coal Market Prices, June 2006 – February 2009

Source: TNB. (Note: RB, NEWC and JPU and K1, K2 are coal indices for Richard's Bay, South Australia; Newcastle; Japanese Power Utilities; and Kalimantan.)

In addition to uncertainties arising from volatile price indices, the use of coal brings with it the environmental hazard of enhanced carbon dioxide emissions as clearly indicated in Figure 4.22.

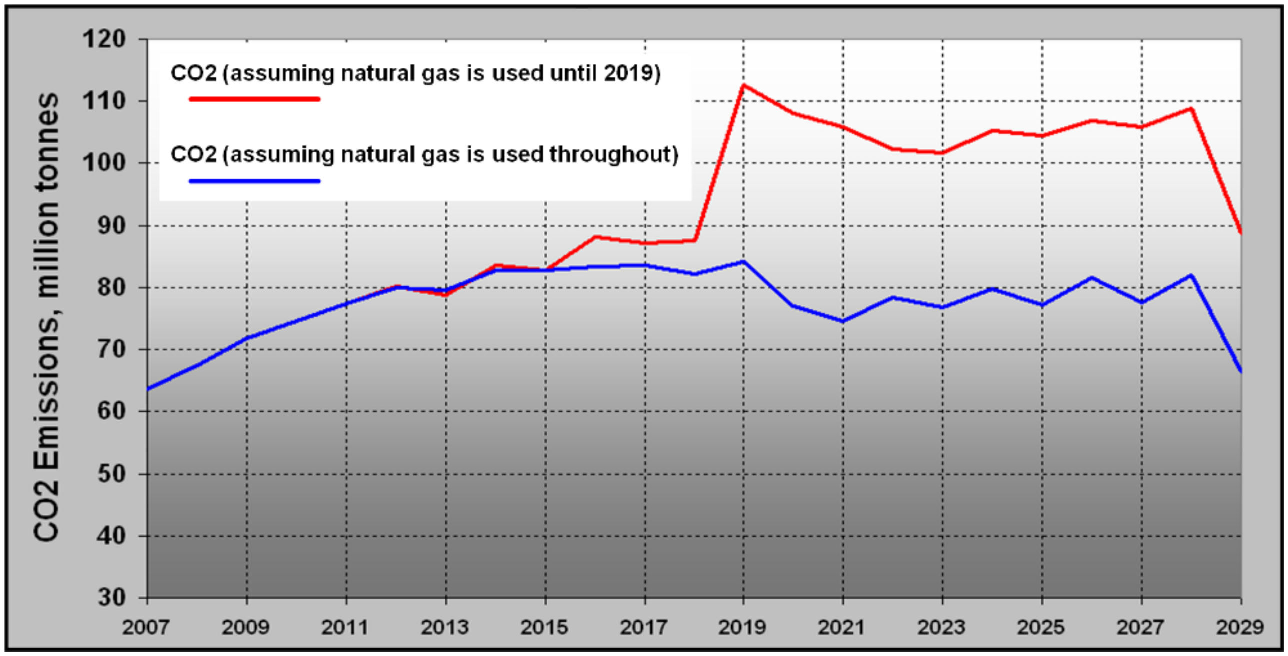


Figure 4.22: Projection on $CO_2$ Emissions from Coal Consumption for Power Generation, 2007-2029

Source: TNB

Summarizing, the major issues facing the utilization of coal for power generation are:

- Over reliance on this commodity;
- Risky supply, both in terms of availability and political ramifications;
- Volatile prices that occasion a risky FOREX element;
- Scarcity of suitable sites for future coal plants; and
- Environmental concerns and limitations imposed by enhanced climate-change regulations.

Some possible solutions to the above-mentioned issues are:

- Continuous strategic procurement of the commodity;
- Greater diversification to other sources;
- Strategic investment in coal mines; and
- The use of advanced technology e.g. CCS[17] and IGCC[18] in the longer term.

[17] Carbon capture sequestration
[18] Integrated gasification combined cycle

# RENEWABLE ENERGY (RE)

During the period covered by the 8MP (2000-2005), the *Five-Fuel Diversification Policy* of 2001 came into force. This policy identified RE as the fifth fuel in the national energy supply mix[19]. One key target at that time was to be able to generate at least 5% of the country's electricity supply (amounting to some 500 MW) from RE resources by 2005.

By the time the 9MP (2005-2010) came around, electricity derived from RE had merely appeared on the horizon. The government then decided to set more realistic figures of 300 MW and 50 MW for Peninsular Malaysia and Sabah, respectively, by 2010. No such plan was devised for Sarawak since its huge hydroelectric potential was obviously ready to meet and exceed state-wide demand in the short and medium terms.

## The Small Renewable-Energy Power (SREP) Programme

In order to achieve the national goal of diversification with respect to energy resources, a *Special Committee on Renewable Energy* was set up in 2001. This body was mandated to flesh out the government's strategy to intensify the development of RE as the fifth fuel resource. The *Small Renewable-Energy Power (SREP) Programme* was launched under the initiative and watchful eye of this committee. The focus of this programme was the expeditious incorporation of the output of small RE-based power plants into the National Grid. The word *small* in this context meant a generating capacity not exceeding 10 MW. Through its *One-Stop Centre* at the premises of the Energy Commission, the committee would assist the operators of small power generation plants to sell electricity to the power utility companies.

RE resources include biomass, solar energy, mini-hydroelectricity, wind energy and biogas. During the middle of the last decade, the then Ministry of Energy, Water and Communications identified biomass and solar energy as the key *initial* players in the local RE scene. It was determined that the country's principal biomass resources would be palm oil residues, wood residues, rice husks and municipal waste. These would be used in CHP schemes[20] . The total value of biomass resources in Malaysia was estimated then to be more than RM 500 billion over the next 20 years.

The Special Committee on Renewable Energy promptly received and began to evaluate applications from interested parties to launch SREP projects. Figure 4.23 shows the *status quo* of approvals in late 2005.

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[19] The national energy supply mix refers to the various energy resources that the country depends upon and their relative contributions to the overall supply.

[20] CHP is combined heat and power, a technique in which the unused heat energy generated in a power station is used to heat up water for various purposes such as pre-heating, domestic heating, etc.

| RE Source | Approved Applications | Grid-connected Capacity, MW | % |
|---|---|---|---|
| Biomass: | | | |
| • EFB | 22 | 165.9 | 52.5 |
| • Wood Chips | 1 | 6.6 | 2.1 |
| • Rice Husks | 2 | 12.0 | 3.8 |
| • Municipal Solid Waste | 1 | 5.0 | 1.6 |
| • Mixture | 3 | 19.2 | 6.1 |
| Landfill Gas | 5 | 10.0 | 3.2 |
| Mini Hydro | 26 | 97.4 | 30.8 |
| Total | 60 | 316.1 | 100.0 |
| As of August 2005, no SREP projects involving wind energy had been approved. | | | |

Figure 4.23: Status of SREP Projects Approved by the Special Committee on Renewable Energy as at August 2005

Source: KeTTHA

Of the 60 SREP projects approved by the committee, only 10 developers have thus far applied for licenses to proceed with the implementation of their projects. All these applications have been approved, bringing with them a total generating capacity of 51.55 MW. Each of these applications has necessitated the signing of an REPPA[21] with TNB in 2008. Due to a number of reasons, the remaining 50 projects have yet to be implemented.

In addition to the 10 projects implemented under the SREP Programme, TNB has also initiated a number of other small RE-based power-generation schemes. These are:

- Mini-hydroelectric schemes totalling 13.643 MW, involving 44 sites in Peninsular Malaysia with unit capacities in the range 48 kW to 1.1 MW;
- Solar BIPV[22] schemes totalling 168.515 kW, involving 16 sites with unit capacities in the range of 3.06 to 92.01 kW;
- Solar PV[23] (TNB Mini-Grid) schemes totalling 1.231 MW, involving 25 sites in Peninsular Malaysia and Sabah with unit capacities in the range of 10 to 250 kW; and

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21 Renewable energy power purchase agreement

22 Building-integrated photo-voltaic

23 Photo-voltaic

- Wind (TNB Mini-Grid) - one 200 kW site at Pulau Perhentian, Terengganu.

Figure 4.24 gives the total grid-connected power derived from RE.

| RE Source | Capacity, MW | % |
|---|---|---|
| Mini-Hydro | 22.4 | 33.5 |
| Biogas (Landfill) | 2.0 | 3.0 |
| Biomass (Palm Oil Mill Solid Wastes) | 35.8 | 53.6 |
| Municipal Solid Waste | 5.0 | 7.5 |
| Solar PV (BIPV) | 0.2 | 0.3 |
| Solar PV (TNB Mini-Grid) | 1.2 | 1.8 |
| Wind (TNB Mini-Grid) | 0.2 | 0.3 |
| Total | 66.8 | 100.0 |

Figure 4.24: Existing Grid-Connected Power Generation Capacities from RE in Peninsular Malaysia, April 2008

Source: TNB Roundtable Discussions on Renewable Energy

## The Kyoto Protocol and the CDM

The formulation of the Five-Fuel Diversification Policy in 2001 was an obvious step in the right direction. One year later, in 2002, the government ratified the Kyoto Protocol. This means that our status as "a Non-Annex 1 country" allows us to utilize the *Clean Development Mechanism* (CDM) to reduce domestic carbon dioxide emissions. We can also expect to benefit from the ready transfer of advanced technologies from developed (Annex 1) countries.

# TRANSPORTATION

At the beginning of this chapter, the data in Figure 4.1 clearly represented the transportation sub-sector as being responsible for 37% of the national primary energy demand. It follows that any attempt to raise EE in the way this country's estimated 17 million vehicles are designed and run will have far-reaching effects on the energy sector. There are huge opportunities calling for the application of STI expertise to enhance EE from its currently dismal values and to reduce GHG (greenhouse gas) emissions.

## The use of bio-fuels

The internal combustion engine, using mostly liquid fuels, will continue to be the dominant power source for road-based vehicles until 2030. Within the range of liquid fuels available today, bio-fuels provide the best option for the reduction of the transportation industry's gargantuan GHG footprint.

Bio-fuels are combustible liquids that are derived from biomass. The principal biomass-derived fuels commercially available today and suitable for road transport are:

- ethanol, for spark-ignition engines [24]
- bio-diesel, for compression-ignition engines [25]

Ethanol is just one member of an entire class of organic liquids called alcohols. It is derived from the chemical decomposition of starch and sugar. Most internal combustion engines that run on petrol (also called gasoline) can be modified at minimal cost to run on ethanol.

The term bio-diesel strictly refers to a form of diesel fuel that is derived from vegetable oil or animal fat. The most widely used bio-diesel is *methyl ester*. Blending this with standard petroleum-based diesel gives a fuel that works very well with all diesel engines. Such blends are used in many countries in vehicles and industries to reduce dependence on fossil fuels and mitigate the risks associated with the escalation of crude oil prices.

The National Bio-Fuel Policy which was launched in March 2006 promotes the use of ENVO diesel, a Malaysian variant of blended fuel consisting of a mix 5% *palm olefin* (derived from palm oil) and 95% standard diesel (derived from petroleum). The policy was aimed at nation-wide implementation by 2010. Palm olefin was preferred to methyl ester for two reasons:

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[24] Petrol engines use a spark produced by a spark plug to ignite a fuel-air mixture.

[25] In diesel engines, high compression causes a fuel-air mixture to self-ignite.

- much lower processing costs (the former is natural, the latter artificial); and
- availability as an offshoot of the local palm-oil industry.

Malaysia's use of palm olefin as a component of blended fuel may be short-sighted as it could backfire on the government's policy of promoting the use of diesel-powered vehicles. This is because the long-term effects of palm olefins on engines are relatively unknown at this point in time thus raising the issue of performance warranties. In the absence of reliable scientific data, engine manufacturers are comfortable with providing warranties only if methyl ester is used instead of palm olefins. It is thus imperative for the government to reconsider using methyl ester for blending purposes.

# CHAPTER FIVE Major Issues and Shortcomings

In this chapter, the reader will be guided into re-examining the energy sector of the national economy from a specific angle. This exercise will entail analyzing the current availability of STI resources as well as the programmes and initiatives being undertaken by the government to develop the same. The purpose of doing this will be to identify a number of issues and shortcomings that have been hampering the existing approach. Once this is done, a number of suggestions on how to fix the beleaguered system can be considered. This will be a necessary first step towards optimizing the STI resources currently at our disposal as well as further developing the national STI resource base.

In attempting to do this, the nation will have to summon the intellectual and political wherewithal necessary to overcome the many weaknesses that have been infused into the present system. A summary of the activities of the various government organizations that are affecting the current availability of STI resources and the development of them will first be attempted. Subsequently, a number of concerns will be raised about the current STI availability-and-development scene.

This chapter is intended to assist all energy-related ministries and agencies of the government in the preparation of their plans to expand and improve the STI resource base of the country.

# THE POLICIES

## The Knowledge-Based Economy Master Plan (2002)

This plan, also known as the K-based Master Plan, was prepared by the Economic Planning Unit (EPU) in 2002. The full text can be found in Appendix 6.1. The plan attempted to identify the serious shortcomings in the availability of STI resources at that time. It also noted the nation's limited capacity to develop them. Quite appropriately, the plan also provided a set of recommendations intended to fix the shortcomings.

The Master Plan was built around *seven strategic thrusts*, paraphrased as follows:

- Cultivate and secure the human resources necessary for the existence and growth of a K-based economy.
- Establish the institutions necessary to champion, mobilize and drive the transition to a K-based economy.
- Ensure that the incentives, infrastructure and infostructure necessary to support the optimal application of knowledge to all sectors of the economy are in place.
- Dramatically increase the capacity for the acquisition and application of science and technology in all areas.
- Ensure that the private sector functions as the vanguard of the development of a K-based economy.
- Develop the public sector into a K-based Civil Service.
- Bridge the knowledge and digital divides.

The main text of the plan concedes that all the thrusts are to be considered important. However, it represents the "need to secure and cultivate the most crucial asset in the K-based economy – human capital" as being of *paramount* importance. This clearly identifies the *first* thrust as having pre-eminence over all the others. The text goes on to identify the most *immediate* thrust as being the establishment of the institutional drivers that would shepherd the transition to a K-based economy. This is clearly the *second* thrust. The study team takes the liberty to assume that the term "K-based" everywhere in the text of the plan can be read as "STI-based"

In reviewing the outworking of the Master Plan since its formulation, the study team has made the following observations.

- First, the plan was "spot on" in identifying the main shortcomings that were present in the STI resource base in 2002.

- Second, the recommendations made to fix the shortcomings were appropriate.
- Sadly, those shortcomings are still present for the most part today, several years later. For example, STI education and human capital are both still woefully inadequate on a national basis.
- Similarly, the recommendations made in the plan have been minimally implemented, at best.

### The National Science and Technology Policy II (2003)

This policy was formulated in 2003 by the Ministry of Science, Technology and Innovation (MOSTI). The full text of the policy is carried in Appendix 6.2. The strategic thrusts that formed the backbone of the policy were exactly what one would have expected to find in a document dealing with a developing country's national science and technology agenda.

- Strengthening research and technological capacity and capability.
- Promoting commercialization of research output.
- Developing human resource capacity and capability.
- Promoting a culture of science, innovation and techno-entrepreneurship.
- Strengthening the institutional framework for the management of STI development and for monitoring the implementation of STI policy.
- Ensuring widespread diffusion and application of technology that leads to enhanced market-driven R&D aimed at adapting and improving technologies.
- Building competence for specialization in key emerging technologies.

The excellence of the plan notwithstanding, the basic question to be asked is, "What progress has been made in achieving the targets identified by the thrusts?" The honest answer several years down the line is, "Not much". Yet, the purveyors of the plan expressed their conviction that (1) proficiency in the field of STI does not happen by chance - it must be *made* to happen, and (2) decisions on STI development must be made based on well-informed deliberations and not on exigencies. Clearly, the current institutional framework for STI is characterized by a lack of resources devoted to STI-policy analysis. Added to this is the bureaucratic inertia that stems from the diffusion of responsibilities throughout various arms of the government. Clearly, there is an urgent need to put in place a well-defined system of managing and monitoring the national STI agenda. Ability, agility and accountability must underpin such a system.

The study team is of the opinion that it is necessary to ascertain the level of progress hitherto made in realizing each of the seven strategic thrusts of the policy. In order to do this, the government should fund an independent review of the progress of the policy.

The review must document the level of success and/or failure of each thrust, identify the causative factors behind failure and spell out the changes necessary to guarantee success. Needless to say, the review must be factual, thorough, incisive and constructive in its findings, conclusions and recommendations. The review could be conducted *on a sample or on all* of the eleven industry sub-sectors identified as key areas for development. The cost of conducting such a review would range from RM 5 million to RM 15 million, depending on its extent. Since there has not been much progress with respect to clearly-stated targets, a review to identify the reasons for failure should be undertaken so as to ensure that future plans will be successful.

### National Higher Education Action Plan (2007-2010) [26]

This action plan, formulated by the Ministry of Higher Education (MOHE), was designed to highlight the strategies of the broader-based *National Education Blueprint (2006-2010)*. Like its predecessors, it is also defined by seven strategic thrusts. These are:

- Widening access to higher education and enhancing equity in the broadest possible terms.
- Improving the quality of teaching and learning.
- Enhancing research and innovation.
- Strengthening institutions of higher education.
- Intensifying internationalisation.
- Enculturation of lifelong learning.
- Reinforcing the delivery system in the field of higher education.

A number of initiatives in the plan were designed to skew the tertiary education system to play a leading role in the broadening and deepening of the STI resource base in the country.

Some of these initiatives were:

- to grant universities a greater level of autonomy and accountability so that they can become more dynamic institutions of learning;
- to establish the right process for selecting university faculty members;
- to establish a remuneration system based on merit;
- to strengthen the performance-review process for educators;

[26] The full text of the plan is available at http://www.mohe.gov.my/transformasi/

- to require top-tier universities to develop excellent R&D facilities that result in commercialization;
- to increase funding for STI courses and for the establishment of a collaborative national innovation system; and
- to create ‘apex’ universities that can match the stature of the best learning institutions in developed countries.

The action plan, as an expression of the blueprint, is an excellent one as indicated by its key elements. However, a number of shortcomings are evident.

- Few of the strategies address the urgent need to deepen and broaden the STI resource base of the country.
- The intention to narrow the gap between locations, school types and races has only resulted in an ‘averaging down’ for the teaching of Science and Mathematics as reflected in the decision to revert to Bahasa Malaysia as the medium of instruction for these vital subjects.

Moreover, the plan does not appear to have achieved its targets. This is reflected by:-

- the continued shortage of technically-trained graduates;
- the large number of university graduates unable to find jobs; and
- the need for many university graduates to undergo vocational training in order to acquire employable skills.

The plan should embody a more strategic approach to improving higher education and a number of related questions have to be asked:

- How many of the stated targets were achieved in the time frame indicated?
- What were the obstacles facing targets that were not achieved?
- What needs to be done to remove obstacles that prevent targets from being achieved?

Any failure to achieve deliverables by their targeted dates must be critically assessed. In this way, amendments can be written into the next higher education plan so as to give it a greater measure of success than its predecessor.

There also remain a number of broader issues related to education that must be resolved in order to bring about more aggressive STI capacity building.

- The quality of the technical universities in the country must be significantly strengthened by raising the competence level of their teaching faculties.
- The pursuit of an STI-related career at tertiary level must be rooted in the

imparting of the correct scientific and mathematical *orientation* at primary and secondary levels. The government's decision to revert to Bahasa Malaysia as the medium of instruction will severely compromise this for reasons inappropriate to articulate here.

- There appears to be an even more serious problem in the making as a consequence of the decision on the teaching medium. The country is certain to face an acute shortage of primary and secondary teachers qualified to teach Science and Mathematics. Clearly, for the next 5 to 10 years, there will be a struggle to develop this particular human resource and the number of competent students with basic scientific and mathematical skills entering tertiary education will be minimal. A longer-term consequence of this will be a reduced volume of quality STI graduates in the next 10-15 years.

This MOHE action plan provides a very good description of what needs to be achieved as well as the deliverables, or targets, which will represent achievement. The plan clearly articulates a number of *actions* that must be taken in terms of "what", "who" and "when." There is, unfortunately, no discussion of "how". The study team suggests that MOHE should hold each party that is to be responsible for these *actions* to formally specify *how* these actions will be carried out. This must be done with immediate effect. Then, during the upcoming review of the action plan, progress with respect to each deliverable can be assessed and corrective measures taken.

### MOSTI Strategic and Action Plan (2010-2020)

MOSTI is currently in the process of drafting a brand new plan to cover the period 2010 to 2020. While some progress has been made in each of the *previous* plans, it is clear from anecdotal evidence and the observations of the study team that *real* progress has been minimal. If this new MOSTI plan is not to meet the same fate as its predecessors, two pressing questions must be asked. These are: (1) What have been the causes for the slow development of the STI resource base over the last 10 years? (2) What, in the new plan, is specifically addressing these causes so that it is more likely to succeed?

The full presentation of the plan is carried in Appendix 6.3. The ongoing discussion here seeks to highlight a number of strengths of the plan in the context of the many concerns that have been raised about the limited STI resource base in the country and the hitherto feeble rate of development of this base.

## The Concerns of the Study Team

In examining the current situation in the country with respect to deepening and widening the national STI resource base, the members of the study team found consensus in aggregating twelve specific concerns. The team also found that it would be possible to categorize these concerns into three groups, namely: (1) concerns about the lack of an STI culture; (2) concerns about limited STI development programmes and processes; and (3) concerns about limited government support for the STI development process.

### *Group 1: The Lack of an STI Culture*

- The country does not have an STI culture thus programmes to develop STI human capital are limited.
- STI is generally not promoted and hence not perceived as an attractive field for learning and work.
- Historically, open discussion about how to develop STI resources has been limited.

### *Group 2: Limitations in STI Development*

- In order to achieve an optimal pace of development, STI educational opportunities must be filled with the brightest students. Again, the current practice of quotas and "set asides" continues to plague the educational system.
- There is a limited performance-based management culture. Hence, there is no recognition for good performance and no penalty for poor results. This induces indifference on the part of STI personnel towards quality work.
- There has been no consistent approach to developing STI resources in the country.
- Development of STI resources has not been extended down to the primary education level.
- Although a number of STI development initiatives have already commenced, the capability to thoroughly implement them has been limited.

### *Group 3: Limited Government Support*

- The government appears to have a set mind that limits opportunities for STI students to grow. The problem is exacerbated when those exercising control are not those competent in STI principles.
- Remuneration for top-class STI personnel in Malaysia is very low compared to that in many other countries thus making the field unattractive to students. If at all students enter this field, they typically seek employment outside the country. This problem appears to stem from the mentality of "staying

competitive through low wages" which prevailed when the country's economy relied heavily on the manufacturing sector.

- Government bureaucracy does not nurture innovation. Instead, it renders administrative processes excessive to the point that public sector employees have found a haven in a "make work" environment.
- The only way to produce a highly competent human-resource pool is to practise meritocracy in appointments and promotions but this is hamstrung by racial and religious considerations.

## The Thrusts of the Plan

The study team next considered the seven strategic thrusts in the plan.

***Thrust 1: Developing human capital.***

- Introduce and/or strengthen entrepreneurship courses in the education curriculum.
- Promote cross-border exchange of STI talent.
- Increase dialogue amongst industries, ministries and universities to identify current and emerging STI needs.
- Review the incentives necessary to retain the best and brightest STI graduates.
- Restructure the public administrative service for upward mobility of qualified STI personnel.

***Thrust 2: Utilizing and increasing home-grown R&D, technology acquisition and innovation.***

- Development of a sector-technology roadmap and assisting R&D projects, technology acquisition and innovation through proper funding.
- R&D collaboration programmes.
- Techno-entrepreneur development.

***Thrust 3: Mainstreaming STI, nurturing and developing a culture of creative and innovative thinking.***

- Promote STI policy as one of the (primary) drivers of national development and align it with other development policies.
- MOSTI to act as the lead ministry with respect to the national STI agenda.
- Produce a 5-year technology development plan.

- Facilitate the development of hi-tech SMEs.
- Implement an STI awareness campaign.

***Thrust 4: Enhancing and strengthening alliances between the government, universities, industries and research institutes.***

- Provide a framework for a common platform to coordinate all STI development activities.
- Establish "centres of excellence" that are independent of government procedures.

***Thrust 5: Strengthening research, development and commercialization.***

- Establish a research-management process that deals both with projects and the development of research personnel.
- Promote a "brain gain" programme to attract foreign talent to accelerate the development of STI resources.

***Thrust 6: Realizing wealth creation and societal well-being from commercialization.***

- Develop a national coordinating mechanism for innovation.
- Provide cash incentives to researchers for developing innovations.
- Provide training on IP (intellectual property) protection.
- Establish a monitoring process to track and assess innovations.

***Thrust 7: Empowering society through innovation.***

- Develop a "science is fun" programme. This could include stories about inventions and discoveries, hands-on experiments and demonstrations to expose children to science, etc.
- Develop a "mathematics is fun" programme. This could include games with numbers.
- Modify the education system to promote innovation and creativity.
- Adopt a participator approach to prioritizing research programmes.

The study team believes that the thrusts presented above adequately address the concerns raised. This is summarized in Figure 5.1 in which each thrust is presented against a backdrop of the concerns it addresses. It is clear that thrusts 2, 4, 5 and 7 are somewhat limited in scope while thrust 3 is the most crucial of them all, its reach extending across all three groups of concerns.

| | CONCERNS | | |
|---|---|---|---|
| | **Group 1** | **Group 2** | **Group 3** |
| | **The Lack of an STI Culture** | **Limitations in STI Development** | **Limited Government Support** |
| **THRUSTS** | | **Thrust 1:** Developing human capital. | |
| | | **Thrust 2:** Utilizing and increasing home-grown R&D, technology acquisition and innovation. | |
| | **Thrust 3:** Mainstreaming STI, nurturing and developing a culture of creative and innovative thinking. | | |
| | | | **Thrust 4:** Enhancing and strengthening alliances between the government, universities, industries and research institutes. |
| | | **Thrust 5:** Strengthening research, development and commercialization. | |
| | | **Thrust 6:** Realizing wealth creation and societal well-being from commercialization. | |
| | **Thrust 7:** Empowering society through innovation. | | |

Figure 5.1: How the Thrusts of the MOSTI Plan Address the Concerns

Source: Study Team

It appears that the MOSTI plan, if fully implemented, is an excellent one for developing the STI resource base of the country.

## The National Policy on Biological Diversity (1998)

The period prior to 1998 saw staggering levels of economic and industrial growth in this part of the world. These boom conditions raised concerns about sustainability, particularly so with regard to the rich diversity of flora and fauna which tropical countries have been blessed with. Against a backdrop of greed and ambition driving reckless development endeavours that threatened the environment on a large scale, there was a need to put more teeth and muscle into standard EIA (environmental impact assessment) practices. The National Policy on Biological Diversity [27] thus served as a guarantee that the government would "conserve Malaysia's biological diversity and ensure that its components are utilized in a sustainable manner for the continued progress and socio-economic development of the nation."

Despite this responsible initiative on the part of the government, there is no small consensus that all is not well on the conservation horizon. While it is readily understood that all development will negatively impact a nation's biodiversity one way or another, it is also expected that unless the *trade off* in terms of the ensuing benefits can be proven beyond any shadow of doubt, large projects that are seen to compromise the environment simply must not be undertaken.

A case in point is the initiation of any new major hydroelectric scheme or the expansion of an existing one, whether in Peninsular Malaysia or in Sarawak. *The clout which the policy currently has must be used to develop a more scientifically powerful biodiversity template that would*

- significantly enhance the analysis of the biodiversity impact of the proposed scheme;
- exhaustively examine the situation in the hinterland of the scheme;
- determine the degree to which the biodiversity is replicated in other areas not impacted by the scheme; and
- guarantee an unbiased, factual and well-informed balance between the value of maintaining that biodiversity and the value of destroying it for the much-needed electrical power it would provide.

Furthermore, the importance and inherent complexity of the biodiversity that exists in equatorial rainforests makes it worthy of much more than a standard EIA formality. Sufficient time and attention must be devoted to the exercise of gathering the necessary information. Unreasonable market-driven deadlines must never be allowed to factor into the process no matter how urgent the perceived need.

Past attempts to bring the policy to bear upon the status quo of 'necessary development' in the country have revealed a number of key governance issues.

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[27] The full text is available at: http://www.arbec.com.my/NBP.pdf

- There is no single comprehensive law pertaining to biodiversity.
- Responsibility for biodiversity matters is spread amongst a number of government ministries.
- There is currently no dedicated agency (or Department) in the country that looks after biodiversity in the country.

To the extent that these weaknesses have yet to be addressed, it will continue to be difficult to challenge those situations in which controversial development activities receive the go-ahead despite the failure to convince concerned parties that a legitimate trade off exists.

### The National Biofuel Policy (2005)

The strategic thrusts of this policy are limited. While there is a sincere ongoing attempt by the government to reduce our dependence on fossil fuels, there does not appear to be an aggressive strategy to replace these with biofuels *wherever possible*. The government should develop a significant export market for this new commodity. It is to be noted that the current initial activities represent a good beginning for biofuels to make their contribution to sustainable development. However, it is imperative to set a target date for the completion of these activities. This will facilitate the updating and strengthening of the policy with more aggressive targets that could be included in an updated sustainable development plan.

### The Third Outline Perspective Plan (OPP 3)

The reader might recall that this plan was presented in some detail in Chapter 3. Way before 2000, this plan correctly identified the need to improve (1) the venture capital resources, (2) the STI resource base, and (3) the R&D capability in the country. However, there was limited discussion as to how these improvements were to be undertaken and who was to be responsible for initiating and managing them.

The OPP 3 clearly articulated a relatively large number of initiatives but failed to provide the *scorecard* that should have been used to gauge the progress of these. *The virtual absence of such a scorecard was and continues to be a major institutional shortcoming that pervades and plagues this country's system of formulating and implementing its plans and policies.* Common wisdom dictates that at any time in a nation's existence, it is imperative to have a 'report card' for all the plans and policies that have been gazetted so that the government will have a firm basis for deciding whether corrective action is needed, and if so, exactly what steps should be taken. On a positive note, the recent government announcements with regard to KPIs and KRAs represent the first stage in the development of these long-awaited 'report cards'. Such measures to collect performance-related information will go a long way towards the successful implementation of any sustainable development plan.

The OPP 3 also called for the development of an extensive national *knowledge and skill base*. This has clearly not been achieved. Consequently, all the plans that have been put into place over the years have not had the benefit of being able to draw input from a huge STI resource base that was expected to have been in place some years ago.

## A Critical Overview of All the Plans and Policies Reviewed

At this point, the reader is invited to step back a little and join the study team in a critical overview of the many plans and policies that have been unveiled. Through the deluge of information that has emerged from the innumerable goals and objectives and thrusts and targets, the team has reached consensus that the Malaysian planning processes and development endeavours over the years have been weighed down by a number of serious shortcomings.

- It is abundantly clear that the various policies and plans lack a strong *sustainability* component.
- Reliable mechanisms to monitor how the production and utilization of energy impacts sustainable development have been seriously lacking.
- Since sustainable development is a long-term concept with a lengthy gestation period and no immediate payoff, there is minimal interest in it.
- Very little attention is being paid to developing the STI resources needed to support the long-term processes that define sustainability.
- Sustainable development is the latest 'fashion' on the development scene so everyone is interested in talking about it in order to look responsible but there is seldom any real action.
- There are many objectives, goals, thrusts and initiatives but their implementation remains an issue which ought to be reviewed.
- The country simply does not have an R&D culture.
- There is limited coordination amongst the various ministries and agencies, the consequence of which has been minimal co-operation and sharing of information.
- Historically, science and technology have not featured prominently in the economic and national development agenda. For example, GLCs are viewed only as sources of revenue, not of R&D.
- The faithful implementation of sustainable development plans is at risk from the prevailing bureaucratically-driven mind-set which often results in unnecessary and unproductive effort.

On the brighter side, the National Green Technology Policy seems to have all the elements necessary to address and rectify most of the shortcomings identified and thus provide the country with a strong governance basis for sustainable development. The strengths of this policy will become quite readily apparent in Chapter 8 when we see many of its features being reflected in a host of commendable practices for sustainable development found in a number of countries around the world. Then, in Chapter 9, the policy will be re-visited in the context of a national framework aimed at guiding the nation’s development endeavours well into this century.

# Renewable Energy

The Malaysian Government appears to be serious in its efforts to increase the contribution of renewable energy (RE) to the national energy mix. To date, however, there are still several barriers and challenges facing those who wish to venture out in this bold new direction. The study team is of the opinion that these obstacles can be overcome by appropriate governance measures that are severely lacking at this time. These institutional and other weaknesses are dealt with here and appropriate recommendations made in Chapter 8. The study team strongly urges the government to act expeditiously on those recommendations.

## Security of Raw Fuel Supplies

Biomass can be used as a raw fuel for the generation of electricity. However, the reliability of biomass supplies is a major issue facing RE power-project developers. This is because these fuel suppliers are not bound by any long-term agreements with the project developers. A case in point is the use of EFB (empty fruit bunches) and POME (palm oil mill effluents) in the power industry. The flow of these materials from the palm oil mills to the developers depends on the variations in output capacity and operation of the former. These variations occur in (1) volume and (2) fuel-related quality of both EFB and POME on a day-to-day basis. If these variations are due to natural causes such as the seasonal nature of the oil-palm fruits, nothing much can be done. However, such variations are often due to poor management of the mills. Furthermore, there are uses for EFB and POME other than as fuel for the generation of electricity. Primary amongst these would be the processes for the manufacture of pulp, paper, medium-density fibre-board (MDF), compost and fertilizers.

The negative effects of these problems on the laudable efforts to substitute conventional fuels with biomass can be mitigated somewhat by suitable regulatory legislation. However, the absence of standard contract procedures regarding the supply and pricing of EFB, POME and other biomass supplies serves only to exacerbate the problems.

## Renewable Energy Power Purchase Agreements

The current system in operation in the country for RE power-project developers is the signing of a Renewable Energy Power Purchase Agreement (REPPA) between the developer and TNB. This arrangement is fraught with problems in three areas.

### (1) Returns for RE Developers

The sales price of RE-derived electricity is a major issue for RE developers. This is because the fixing of this price involves a bargain between the developer (the seller) and TNB (the buyer). The former naturally seeks an acceptable level of profit while the latter is concerned with the magnitude of subsidy it has to carry in order to support the government's Five-Fuel Diversification Policy. The present sales price of 17-21 sen per kilowatt-hour is close to or below the unit cost of production. Besides, this price structure unrealistically assumes a static cost of production over the long term covered by the REPPA. The overall consequence of this scenario is lack of interest on the part of potential developers/investors.

### (2) Financing from Banks

There is another form of negative impact on RE project developers. Under the current terms, most REPPAs do not provide a cash flow that is robust enough to satisfy bankers. Moreover, some of the conditions imposed on the banks discourage them from making the much-needed investment in such projects. One of the more 'notorious' of these conditions is the "Take AND Pay [28] " payment scheme. Another is the non-inflationary fixed tariff for the concession period. There are also other "non-bankable [29] " conditions that prevent funds from being secured. Clearly, each REPPA is in itself a hindrance to the sourcing of finance to make it work. This is indeed a situation that needs scrutiny.

### (3) Cost of Development

RE developers are generally small companies (SMEs) with limited resources. Enthusiasm is therefore contingent upon securing funding as quickly as possible since this will involve minimal running costs (i.e. cost of development) while negotiating with the banks. But such negotiations generally take a long time. This places RE developers at a serious disadvantage vis-à-vis the gigantic IPPs (independent power producers). It is important to note that apart from the scale of production, RE projects are no different from IPP projects in that both involve similar processes to arrive at a "bankable" stage. However, the "big boys" are financially resilient enough to survive the long negotiation period while the "small players" do not have the capacity to see the process through. The end result is that all initiative is often abandoned.

## Standard Subsidy Schemes Denied to RE Developers

Every type of energy-supply scheme currently in operation has benefited from governmental assistance in its start-up phase. RE-based schemes should be no exception.

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[28] A "Take AND Pay" scheme can also be referred to as a "Take IF Offered" scheme. This requires payment only if the product is produced. The guarantee in cash flow to the supplier depends on how certain the supplier can be about delivering its product.

[29] Inappropriate or unworthy of acceptance by a bank.

Currently, massive support in the form of subsidies and export credits is still being given to developers using conventional energy sources. If RE-schemes are to be economically viable, it is important that they receive the same treatment as fossil-fuel-based projects. At the very least, all subsidies for the latter should be gradually phased out. This policy shift will “level the playing field” so that RE-developers can compete fairly with others. The fact that the government has allowed the present disparity to exist raises several questions that should not be answered here.

### Lack of Accessible Financing Schemes and Uncertain Financial Viability

It is currently difficult to obtain financing for biomass-based power-generation or CHP projects in Malaysia. One possible reason is that financial institutions in the country are unfamiliar with the potentially high risks that such business ventures entail. Only a few of the existing technology-financing schemes include RE in their investment portfolios. Based on past experience, such schemes usually require a long application and approval process. This is a powerful deterrent to RE project developers.

Integration with the National Grid is another stumbling block for the RE developer. Although a number of biomass-based power-generation and CHP schemes have been up and running in the palm oil industry for some time, attempts to sell power to TNB have never been successful. This is because of (1) technical considerations connected with instability of supply, and (2) unfavourable selling rates. So, unless a fair price is mutually agreed upon between TNB and the potential developers, biomass-based power-generation/CHP will continue to be an unattractive business venture. As with other RE-based technologies, negotiations are ongoing to create “a more level playing field”.

In the pages that follow, we present summaries of the issues and shortcomings identified in the renewable energy scene categorized according to fuel source. For each category, we identify the source material as well as the dimension under which the issue/shortcoming falls. The figures are listed below:

- Figure 5.2: Biofuels
- Figure 5.3: Biomass
- Figure 5.4: The SREP Programme
- Figure 5.5: Mini Hydroelectric Power
- Figure 5.6: The Solar Photovoltaic (PV) Industry
- Figure 5.7: Energy Efficiency (EE)
- Figure 5.8: Renewable Energy (General)
- Figure 5.9: Energy (General)

| SUMMARY OF ISSUES/SHORTCOMINGS | |
|---|---|
| **SOURCE** | **CODE** |
| World Energy Outlook, 2009, International Energy Agency | WEO |
| Brainstorming Session on Renewable Energy, 2009, MNC/CIGRE Malaysia | MNC |
| DANIDA Study on SREP Programme and RE Development, 2006 | DAN |
| National Renewable Energy Policy and Action Plan, KeTTHA | NRE |
| National Energy Efficiency Master Plan, KeTTHA | NEE |
| Technology and Alternative Energy, Resource Magazine | RMg |
| Malaysia - Top 5 Global PV Industry, 2009, PTM | TOP |

| Categories |
|---|
| Governance, Leadership & Accountability |
| Legal Framework |
| Status Quo Structures |
| Economic/Financial |
| Mind Set |
| Expertise & Experience |
| Inherent Drawbacks |

| ISSUE/SHORTCOMING | SOURCE | | | | | | |
|---|---|---|---|---|---|---|---|
| The high cost of production (i.e. processing) which becomes apparent whenever oil prices are low. | WEO | | | | | | |
| The best selling price that biofuels can command is generally too low to cover the costs of procuring the feedstock and operating the processing plants. | WEO | | | | | | |
| Credit for starting and operating biofuel-processing plants is generally in the form of high-interest loans. | WEO | | | | | | |
| There is restricted access to finance because banks are generally 'nervous' about this new form of investment. | WEO | | | | | | |
| There are limits on the amount of fuel that can be absorbed by gasoline and diesel-blending pools. | WEO | | | | | | |
| There are regulatory uncertainties based on doubts about the environmental sustainability of first-generation biofuel-processing technology. | WEO | | | | | | |

Figure 5.2: Biofuels

| SUMMARY OF ISSUES/SHORTCOMINGS | |
|---|---|
| **SOURCE** | **CODE** |
| World Energy Outlook, 2009, International Energy Agency | WEO |
| Brainstorming Session on Renewable Energy, 2009, MNC/CIGRE Malaysia | MNC |
| DANIDA Study on SREP Programme and RE Development, 2006 | DAN |
| National Renewable Energy Policy and Action Plan, KeTTHA | NRE |
| National Energy Efficiency Master Plan, KeTTHA | NEE |
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| Malaysia - Top 5 Global PV Industry, 2009, PTM | TOP |
| Governance, Leadership & Accountability | |
| Legal Framework | |
| Status Quo Structures | |
| Economic/Financial | |
| Mind Set | |
| Expertise & Experience | |
| Inherent Drawbacks | |

| ISSUE/SHORTCOMING | SOURCE | | | | | | |
|---|---|---|---|---|---|---|---|
| Uncertainties in the availability and cost of biomass fuel supplies (EFB, POME, municipal waste, etc.) present a major challenge in developing large-scale biomass-based power-generation plants. | | MNC | | | | | |
| There are other more profitable uses for EFB and POME (e.g. in the manufacture of pulp and paper) thus making these fuels expensive for biomass-based power-generation plants. | | MNC | | | | | |
| Bankers, most of whom are generally ultra-conservative, are simply not keen on funding biomass-based projects because of the many uncertainties. | | MNC | | | | | |
| It has been established that most of the biomass-related data for early projects were incorrect in that figures were "made to look good". It is thus difficult to make informed decisions about how to develop this evolving sub-sector. | | MNC | | | | | |
| Real expertise in the setting-up of biomass-based power-generation plants is severely lacking. In one actual case, the power output was less than 70% of the expected value. | | MNC | | | | | |
| Some of the existing pilot power plants were built with the cheapest equipment available. The resulting failure of such projects severely compromises the future of the industry in terms of securing funding and gaining public confidence. | | MNC | | | | | |

Figure 5.3: Biomass

| SUMMARY OF ISSUES/SHORTCOMINGS | |
|---|---|
| **SOURCE** | **CODE** |
| World Energy Outlook, 2009, International Energy Agency | WEO |
| Brainstorming Session on Renewable Energy, 2009, MNC/CIGRE Malaysia | MNC |
| DANIDA Study on SREP Programme and RE Development, 2006 | DAN |
| National Renewable Energy Policy and Action Plan, KeTTHA | NRE |
| National Energy Efficiency Master Plan, KeTTHA | NEE |
| Technology and Alternative Energy, Resource Magazine | RMg |
| Malaysia - Top 5 Global PV Industry, 2009, PTM | TOP |
| Governance, Leadership & Accountability | |
| Legal Framework | |
| Status Quo Structures | |
| Economic/Financial | |
| Mind Set | |
| Expertise & Experience | |
| Inherent Drawbacks | |

| ISSUE/SHORTCOMING | SOURCE | | | | | | |
|---|---|---|---|---|---|---|---|
| Tariffs paid by consumers are not adequate to provide investors with the expected minimum returns on their investments. | | | DAN | | | | |
| Current provisions in the REPPAs are unfavourable to SREP project developers in three dimensions: | | | DAN | | | | |
| • *Institutional: (1) There is limited interest in such projects. (2) Connection to the National Grid is non-transparent. (3) TNB has been given the authority to set an upper limit on the power which an RE-based project is allowed to feed into the National Grid. This discourages the owners of medium-sized RE projects that are outside the existing support schemes.* | | | DAN | | | | |
| • *Financial: (1) The incentives are insufficient to attract investment. (2) The sourcing of finance is always a difficult endeavour. (3) Fuel costs are always uncertain since suppliers of biomass can find more lucrative markets elsewhere.* | | | DAN | | | | |
| • *Technical: (1) Local expertise is limited. (2) The current biomass-boiler technology being employed is under-developed. (3) Long distances from fuel centres (mills) to power plants escalate production costs.* | | | DAN | | | | |
| There is no security of fuel supply i.e. long-term supply is not guaranteed. | | | DAN | | | | |

Figure 5.4: The SREP Programme

| SUMMARY OF ISSUES/SHORTCOMINGS | |
|---|---|
| **SOURCE** | **CODE** |
| World Energy Outlook, 2009, International Energy Agency | WEO |
| Brainstorming Session on Renewable Energy, 2009, MNC/CIGRE Malaysia | MNC |
| DANIDA Study on SREP Programme and RE Development, 2006 | DAN |
| National Renewable Energy Policy and Action Plan, KeTTHA | NRE |
| National Energy Efficiency Master Plan, KeTTHA | NEE |
| Technology and Alternative Energy, Resource Magazine | RMg |
| Malaysia - Top 5 Global PV Industry, 2009, PTM | TOP |

| |
|---|
| Governance, Leadership & Accountability |
| Legal Framework |
| Status Quo Structures |
| Economic/Financial |
| Mind Set |
| Expertise & Experience |
| Inherent Drawbacks |

| ISSUE/SHORTCOMING | SOURCE | | | | | | |
|---|---|---|---|---|---|---|---|
| There is poor coordination between the water authorities and the operators of power-generating plants. There have been instances when weirs have almost been dried out. | | MNC | | | | | |
| Regular inspection and maintenance of power plants and high voltage cables is severely lacking. | | MNC | | | | | |
| Power plants are being made to operate in conditions beyond what they were designed for. | | MNC | | | | | |
| The common practice of entrusting maintenance to a private-sector 'caretaker' results in the 'squeezing of the goose'. | | MNC | | | | | |

Figure 5.5: Mini Hydroelectric Power

| SUMMARY OF ISSUES/SHORTCOMINGS | |
|---|---|
| **SOURCE** | **CODE** |
| World Energy Outlook, 2009, International Energy Agency | WEO |
| Brainstorming Session on Renewable Energy, 2009, MNC/CIGRE Malaysia | MNC |
| DANIDA Study on SREP Programme and RE Development, 2006 | DAN |
| National Renewable Energy Policy and Action Plan, KeTTHA | NRE |
| National Energy Efficiency Master Plan, KeTTHA | NEE |
| Technology and Alternative Energy, Resource Magazine | RMg |
| Malaysia - Top 5 Global PV Industry, 2009, PTM | TOP |
| Governance, Leadership & Accountability | |
| Legal Framework | |
| Status Quo Structures | |
| Economic/Financial | |
| Mind Set | |
| Expertise & Experience | |
| Inherent Drawbacks | |

| ISSUE/SHORTCOMING | SOURCE | | | | | | |
|---|---|---|---|---|---|---|---|
| It appears that the local companies currently involved have neither the ability nor the expertise to deliver high-quality work under tight deadlines. | | | | | | | TOP |
| Very few of the local players actually understand the business opportunities in the industry. | | | | | | | TOP |
| The actual in-country technical expertise in the science of solar photovoltaic cells and panels is very limited. | | | | | | | TOP |
| The price of electricity derived from conventional energy sources is highly subsidized. Unless such subsidies are extended to PV energy suppliers, this fledgling industry will never be financially attractive. | | | | | | | TOP |
| There is great uncertainty over the future price of electricity in Peninsular Malaysia. This sends a discouraging signal to the local PV industry about staying competitive if electricity prices fall. | | | | | | | TOP |
| A national R&D roadmap for PV-generation is currently non-existent. | | | | | | | TOP |
| There is no evidence of coordination or collaboration between academic institutions and the PV industry for relevant R&D. | | | | | | | TOP |
| The current PV-generation targets are too miniscule to have any impact on local supply or demand. This discourages MNCs from considering Malaysia. | | | | | | | TOP |

Figure 5.6: The Solar Photovoltaic (PV) Industry

## SUMMARY OF ISSUES/SHORTCOMINGS

| SOURCE | CODE |
|---|---|
| World Energy Outlook, 2009, International Energy Agency | WEO |
| Brainstorming Session on Renewable Energy, 2009, MNC/CIGRE Malaysia | MNC |
| DANIDA Study on SREP Programme and RE Development, 2006 | DAN |
| National Renewable Energy Policy and Action Plan, KeTTHA | NRE |
| National Energy Efficiency Master Plan, KeTTHA | NEE |
| Technology and Alternative Energy, Resource Magazine | RMg |
| Malaysia - Top 5 Global PV Industry, 2009, PTM | TOP |

Governance, Leadership & Accountability

Legal Framework

Status Quo Structures

Economic/Financial

Mind Set

Expertise & Experience

Inherent Drawbacks

| ISSUE/SHORTCOMING | SOURCE | | | | | | |
|---|---|---|---|---|---|---|---|
| There is no dedicated EE&C (energy efficiency and conservation) Act in the country's legislative framework. This 'vacuum' will render all EE considerations a complete waste of time. | | | | | NEE | | |
| There is no reliable benchmark in terms of energy indices for categories of buildings or industries. | | | | | NEE | | |
| There is no one-stop agency (1) to provide guidance on how to raise EE in particular situations, and (2) to advise on funding mechanisms in support of EE initiatives. | | | | | NEE | | |
| There is no central agency to collate valuable data on individual efforts by responsible companies to enhance EE in their premises and businesses. | | | | | NEE | | |
| Low tariffs as a result of subsidies encourage a culture of energy wastage. | | | | | NEE | | |
| The current situation in which four ministries are responsible for various plans to enhance EE has led to: | | | | | NEE | | |
| • *A fragmented approach that lacks cohesiveness and coordination;* | | | | | NEE | | |
| • *Significant duplication of efforts;* | | | | | NEE | | |
| • *Conflicting objectives and a lack of common direction; and* | | | | | NEE | | |
| • *Insufficient funding support for energy service companies (ESCOs) to carry out performance contracting.* | | | | | NEE | | |
| Funding is still insufficient for the implementation of EE initiatives on a national level. | | | | | NEE | | |
| Funding for various aspects of EE research has been admittedly substantial but hitherto on an ad-hoc basis. | | | | | NEE | | |
| There is lack of effective leadership at all levels in the implementation of EE procedures nation-wide. A case in point was the implementation of MS 1525 for the buildings sub-sector. | | | | | NEE | | |
| There is a serious lack of "champions or agents of change" | | | | | NEE | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| which would aggressively drive the concept of EE into the national consciousness. | | | | | | | |
| Despite the low rate of implementation, EE results were unaccounted for as there was no continual monitoring and verification process. | | | | | NEE | | |
| There is a general attitude of indifference towards EE initiatives as it is common knowledge that the national supply of energy exceeds demand. | | | | | NEE | | |
| There is a general unwillingness on the part of owners of premises to incur further expenditure even if this means higher EE. | | | | | NEE | | |
| The ESCO concept is a good one, and hopefully more such companies will emerge, but the "no cure, no pay" principle requires a paradigm shift in the Malaysian mindset. | | | | | NEE | | |
| Insufficient trained personnel to plan, manage, monitor, support and evaluate EE programmes against objectives and targets. | | | | | NEE | | |

Figure 5.7: Energy Efficiency (EE)

# SUMMARY OF ISSUES/SHORTCOMINGS

| SOURCE | CODE |
|---|---|
| World Energy Outlook, 2009, International Energy Agency | WEO |
| Brainstorming Session on Renewable Energy, 2009, MNC/CIGRE Malaysia | MNC |
| DANIDA Study on SREP Programme and RE Development, 2006 | DAN |
| National Renewable Energy Policy and Action Plan, KeTTHA | NRE |
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| Technology and Alternative Energy, Resource Magazine | RMg |
| Malaysia - Top 5 Global PV Industry, 2009, PTM | TOP |

| |
|---|
| Governance, Leadership & Accountability |
| Legal Framework |
| Status Quo Structures |
| Economic/Financial |
| Mind Set |
| Expertise & Experience |
| Inherent Drawbacks |

| ISSUE/SHORTCOMING | SOURCE | | | | | | |
|---|---|---|---|---|---|---|---|
| When one party has control over the national electricity supply system (read TNB). | WEO | | | | | | |
| RE developers have limited access to the National Grid and are thus victims of the misuse of monopsony power. (A monopsony situation exists when there are many sellers but one buyer.) | | | DAN | | | | |
| At present, there is a clear conflict of interest because TNB has substantial control over sale tariffs thus limiting the influence of RE developers in the same. | | MNC | | | | | |
| The continuation of subsidies for electricity and petroleum-based products stunts the growth of the RE industry. | WEO | | | | | | |
| The absence a 'carbon pricing' mechanism (a penalty system imposed on consumers for leaving a carbon footprint) makes electrical power from conventional sources the natural choice. | | MNC | | | | | |
| RE developers continue to experience difficulty in obtaining planning permission and environmental licensing from the authorities. | WEO | | | | | | |
| RE developers lack financing options at competitive rates. | WEO | MNC | | | | | |
| A situation of information asymmetry exists in the country. There are no institutional measures for the dissemination of information to increase awareness or to assist decision-making and investment in favour of RE. | | | DAN | | | | |
| There is a lack of commitment and awareness by authorities and agencies about the need to increase the role of RE in the national energy mix. | | MNC | | | | | |
| Financial institutions are unfamiliar with RE technologies and are thus hesitant to commit funds without *a priori* evidence that such technologies actually work. | WEO | MNC | | | | | |
| The general public is unaware of RE and its long-term significance. The general perception is that RE is still an experimental idea that will see implementation at some point in the distant future. | | MNC | | | | | |
| The absence of a responsible government agency to establish a policy framework and oversee its implementation hinders the growth of an RE industry. | | MNC | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| The government has no clear and holistic roadmap to develop the RE industry in the country. To date, only fragmented and 'localized' roadmaps exist. | | MNC | | | | | |
| The ministry responsible for achieving targets in the development of the RE industry does not get other ministries involved in a collaborative effort. | | MNC | | | | | |
| The absence of a proper regulatory framework prevents legal action from being taken when the circumstances warrant it. | | | DAN | | | | |
| Oversight and implementational functions are not carried out by separate organizations. Thus, there is an absence of a check-and-balance element in the system. | | | DAN | | | | |
| Existing incentives are not substantial enough to attract genuine interest in the development of RE. | | MNC | | | | | |
| There are no adequate and targetted subsidies for the use of renewable sources of energy. | WEO | MNC | | | | | |
| Credit for financing RE development projects is generally in the form of high-interest loans. | | MNC | | | | | |
| The nature of the market is such that market forces alone cannot be left to drive the progress of the RE industry. | | | DAN | NRE | | | |
| A "business as usual" (BAU) approach is neither sustainable nor productive in the long term. | | | | NRE | | | |
| The existing design of the National Grid cannot accommodate the electrical complexities that large-scale variations in RE-based power generation would bring. | WEO | | | | | | |
| There is evidence that parties who obtain licenses for RE development simply sold those licenses to make easy money. There was a total lack of commitment to establish and develop the project for which the license was given in the first place. | | MNC | | | | | |
| Proper maintenance procedures are hardly followed in existing RE-based facilities. | | MNC | | | | | |
| Design and costing is hardly ever done on a proper "life-cycle" basis. This is probably due to lack of engineering expertise on the part of the license holder. | | MNC | | | | | |

Figure 5.8: Renewable Energy (General)

| SUMMARY OF ISSUES/SHORTCOMINGS | |
|---|---|
| **SOURCE** | **CODE** |
| World Energy Outlook, 2009, International Energy Agency | WEO |
| Brainstorming Session on Renewable Energy, 2009, MNC/CIGRE Malaysia | MNC |
| DANIDA Study on SREP Programme and RE Development, 2006 | DAN |
| National Renewable Energy Policy and Action Plan, KeTTHA | NRE |
| National Energy Efficiency Master Plan, KeTTHA | NEE |
| Technology and Alternative Energy, Resource Magazine | RMg |
| Malaysia - Top 5 Global PV Industry, 2009, PTM | TOP |

| |
|---|
| Governance, Leadership & Accountability |
| Legal Framework |
| Status Quo Structures |
| Economic/Financial |
| Mind Set |
| Expertise & Experience |
| Inherent Drawbacks |

| ISSUE/SHORTCOMING | SOURCE | | | | | | |
|---|---|---|---|---|---|---|---|
| There are innumerable challenges associated with any attempt to diversify an existing power-generation mix. | WEO | | | | | | |
| There are innumerable challenges to developing and maintaining a flexible energy infrastructure that can respond to inevitable changes. | | | | | | RMg | |

Figure 5.9: Energy (General)

# CHAPTER SIX

# STI: R&D, Applications and New Opportunities

## GENERAL CONSIDERATIONS

The reader might recall that the *single over-arching objective* of this Mega Science Study was established in Chapter 1 as being the creation of a high-level framework that will assist the Malaysian Government and the business sector in their bid to take the country to new heights of national sustainable development. In the course of its deliberations, the study team came to the conclusion that there are *two imposing specific objectives* that must be achieved in order to realize that single objective. These are:

- Assessing and analyzing potential energy-related drivers of national development and the roles that energy innovation may be able to play in the same; and
- Undertaking reviews and analyses of the government's various development policies to determine the degree to which they specifically promote an STI approach to sustainable national development.

In order to achieve the first of these specific objectives, it is imperative to identify a number of energy-related drivers. These drivers will be the energy opportunities with the greatest potential for the country. Identifying them involves four steps.

- Gathering information from various published sources and avowed experts to make an initial inventory of the emerging opportunities worth pursuing. It is essential that the country's leaders be certain of *what* they want to do before they start thinking of *how* they want to do it.
- Categorizing these opportunities by time-frame i.e. *when* they are likely to materialize.
- Categorizing these opportunities by *nature* i.e. will they serve to improve the value of products or services, or will they serve as investments to create or expand businesses, or both?
- Evaluating the opportunities in each time-frame and creating a shortlist of those that can be prioritized and pursued.

Figure 6.1 shows some of the criteria that can be used to carry out the abovementioned four-step process. Included against each criterion is a 'measuring tool' in the form of a quantitative or qualitative indicator.

| **Criterion** | | **Quantitative or Qualitative Indicator** |
|---|---|---|
| **1** | Potential to achieve significant reduction in the usage of energy resources | Energy consumed per unit of product or service |
| **2** | Potential market for the energy opportunity with no obvious major competitors | (1) Estimated total sales of product<br><br>(2) Estimated total usage of service<br><br>(3) Number of existing minor suppliers in the market |
| **3** | Potential to support R&D activities in the energy opportunity | Gap between STI resources currently available and those necessary to develop the opportunity |
| **4** | Potential to reduce cost to energy user | Cost per unit of energy consumed |
| **5** | Potential to reduce pollution caused by the production of energy | Volume of pollutants per unit of energy produced |
| **6** | Potential to improve quality of energy product or service at no additional cost | Change in energy quality per unit of energy cost |
| **7** | Potential to improve quantity of energy product or service at no additional cost | Change in energy quantity per unit of energy cost |
| **8** | Acceptable time-frame to roll out the energy opportunity | Time-frame to commercial availability |
| **9** | Acceptable time-frame to pay back the cost of investment or conversion | (1) Time-frame to break even<br><br>(2) Time-frame to first year of profitability |
| **10** | Size of additional R&D cost to commercialization | Total R&D cost to move from today to commercial availability |
| **11** | Size of investment cost to start up business | (1) Cost to set up new business<br><br>(2) Cost to sell and service the new energy product(s) |
| **12** | Potential market size, number of competitors and their respective sizes | Number of competitors offering the same or substantially similar energy products or services |

| | | |
|---|---|---|
| **13** | Potential return on investment | Estimated return on investment and cash flow |
| **14** | Complexity and cost of required distribution network | (1) Structure of the service or distribution network for the product<br><br>(2) Cost to operate sales of energy product or service<br><br>(3) Cost to maintain network |
| **15** | Resources available to develop energy opportunity into commercial product or service | (1) Number of STI-trained or skilled staff needed to support R&D<br><br>(2) Number of STI-trained or skilled staff currently (or soon to be) available |
| **16** | Resources available to sell the product or service and maintain it thereafter | Sales and maintenance requirements for energy product or service |

Figure 6.1: Criteria for Short-listing Opportunities

The *second* specific objective mentioned at the head of this chapter had already been dealt with in Chapter 3.

Having identified, assessed and analyzed a host of potential energy-related drivers of national development in conceptual terms, the attention of the reader is now turned to *actual* opportunities in the various sub-sectors for the application of STI principles and know-how.

# OIL & NATURAL GAS

## Exploration Activities

The application of STI knowledge in deepwater exploration activities off the Sabah coastline has resulted in the discovery of new oil and gas fields. The US-based Murphy Oil Corporation, in particular, has registered great success with the discovery and development of the Kikeh oil field. With new oil production from this field recently coming on-stream, Malaysia's transition from the status of net producer to that of net importer can be pushed back to about 2014. Further STI-based exploration work is likely to result in more discoveries as fundamental data suggest good potential exists in other deepwater and frontier areas.

The oil and gas sub-sector continues to enjoy strong STI leverage upon the national economy in the form of recent technological advancements in exploration and production techniques. Figure 6.2 illustrates some of these techniques.

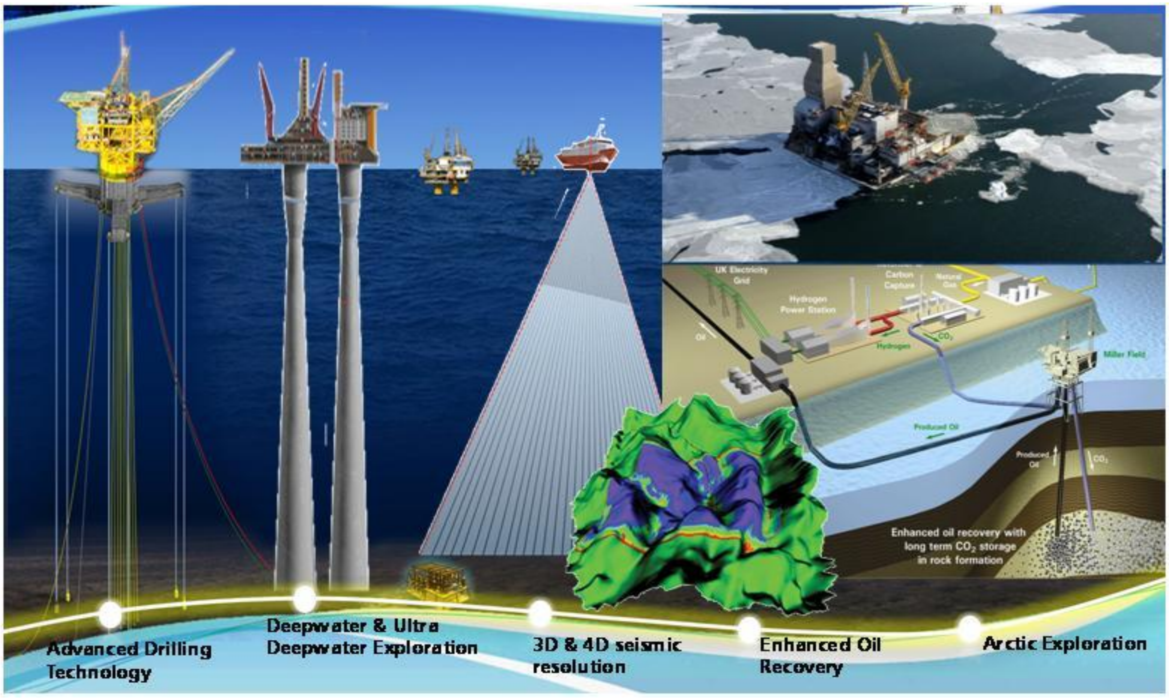


Figure 6.2: STI Leverage in Exploration and Production Techniques

Source: Corporate Information & Research Unit (CIRU), PETRONAS

Advances in deepwater and ultra-deepwater exploration methods have resulted in the discovery of rich oil and natural gas fields in far offshore areas. The latest drilling technology enables the extraction of oil and gas from such fields that were previously inaccessible. Seismic resolution, using powerful sound waves in the 20-100 Hz frequency range, can be used to produce computer-generated three-dimensional (3D) and four-dimensional (4D) images of oil and gas fields 'hidden' deep under the ocean floor. This technology is a gargantuan variation of the use of ultrasound to scan the womb of a pregnant woman! Scientific realities like these mean that more industry players have niche STI capabilities in deepwater exploration, revealing what Mother Earth has in store for us in her subterranean 'womb'. Some of these exploration companies are ready to enter the picture as production-sharing partners. Clearly, the opportunities to discover new undersea reservoirs of oil and gas have been greatly enhanced. STI-based collaboration with a company such as *Petrobras* of Brazil is a possibility worth exploring. The company has been very successful in its exploration activities in the Santos Basin off the Brazilian coast where several oil fields with billions of barrels of reserves were discovered recently.

## Small and Marginal Oil Fields

In Chapter 5, it was indicated that the proven oil reserves of the country in 2008 stood at 5.46 billion barrels. This figure had been aggregated from what was *known* to be recoverable from 163 oil fields discovered. Of these, only 61 had been developed for production. Figure 6.3 provides a geographical representation of the situation. The figure also provides information on gas fields which will be discussed later.

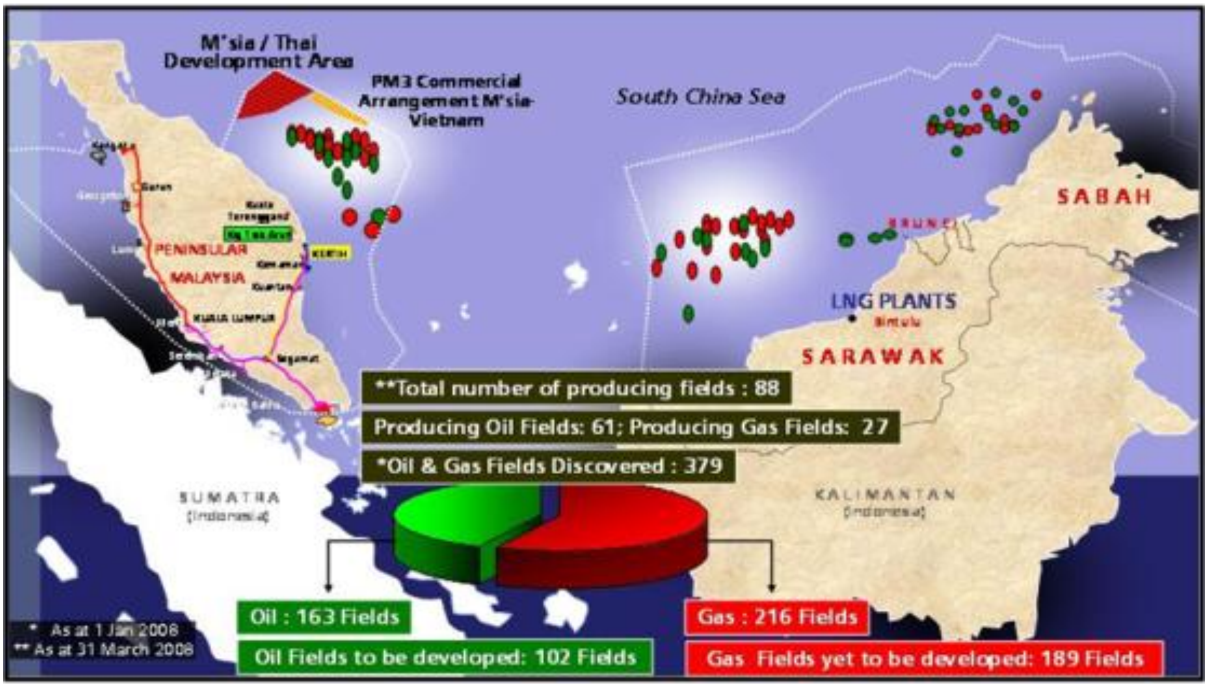


Figure 6.3: Oil and Gas Fields Discovered in Malaysia

Source: Corporate Information and Research Unit (CIRU), PETRONAS, 2008

From an STI-opportunity standpoint, these figures provide some really good news. The number of oil fields that have yet to be developed is 102. But here's the crunch. Most of these fields are regarded as *small* or *marginal*, each with proven reserves of no more than 40 million barrels of OIIP[30]. Since these fields are located in offshore areas, the potentially high cost of development and production rendered them economically unattractive at the time when oil prices were hovering at about USD 30 per barrel. Under such economic conditions,

[30] Oil initially in place

only those oil fields with at least 100 million barrels of OIIP were worth developing in that they guaranteed a 15% rate of return on the investment.

That scenario has been altered significantly by the current price of oil. The deployment of STI resources in the development of small and marginal oil fields is now economically viable. More than that, it is a necessary move to shore up the declining national level of crude oil production in the short-term.

One possible but challenging STI application would be the development of a movable and re-usable tripod jacket or small platform with a sub-sea ‘completion’ to the shore. This facility can be relocated after an oil field has reached its economic limit. This would be a really cost-effective way of developing small and marginal oil fields.

## Enhanced Oil Recovery (EOR) Operations

Some of the existing oil fields in Malaysia have been yielding ‘black gold’ for more than 30 years. These are called ‘mature’ fields and may be reaching their economic limits whereupon they will have to be abandoned. Depending on the quality, size and continuity of each mature reservoir, there are STI opportunities to rejuvenate some of them. The techniques are known as *secondary recovery* or *enhanced oil recovery* (EOR).

Generally speaking, it is not possible to extract more than 35% of the OIIP from an oil field using *primary* recovery techniques. The industry term for this is the *recovery factor*. However, the application of STI knowledge in secondary or tertiary oil recovery techniques could enhance the total recovery factor to 60% or so. One method that is being employed involves the ‘injection’ of an inert gas such as carbon dioxide or nitrogen at extremely high pressure to ‘coax’ more oil out of the well. Since the existing design of production wells and platforms allows a usable life of about 40 years *if well maintained*, STI opportunities to rejuvenate mature oil fields with EOR techniques should be undertaken as soon as possible if they are to be cost effective. At any rate, the economic viability of applying such STI opportunities is very much dependent on the outcome of an *oil field review* which involves a cost-benefits analysis for each intended EOR operation.

## Small, Marginal or Stranded Gas Fields

In Chapter 4, it was also indicated that the country’s *proven* gas reserves in 2008 were 88 thousand billion scf [31]. Figure 6.3 shows that of the 216 gas fields that had been discovered up to that time, only 27 had been operating as *production fields.* This means that the number of undeveloped fields stood at 189. Most of these are small or marginal fields while some are in deep offshore regions. The extraction of gas from these fields has hitherto not been economically viable using conventional gas platforms.

The emerging STI opportunity related to this scenario is the development and perfection of a *floating liquefied natural gas* (FLNG) platform. This facility would collect gas from an offshore well and liquefy it straightaway, then store the finished product on the platform or load it immediately into a tanker. A well designed FLNG platform has to be moveable and re-

[31] standard cubic feet

usable. Once the rate of extraction from the field dips below its economic limit, the entire FLNG facility can simply be towed to the next field.

There are currently no FLNG units in operation although plans are underway to develop and utilize this new technology for offshore Australian and West African fields. The Malaysian Government should provide the impetus for an appropriate agency to utilize this technology in order to ‘monetise’ small, marginal and stranded gas fields with a view to prolonging and sustaining the current level of natural gas production in the country.

## Re-Evaluation of Mature Fields

Gas utilization projects in Peninsular Malaysia and Sarawak came into vogue only in the 1980s. Prior to that decade, the economic value of natural gas was limited. Hence the gas that accompanied the issuance of oil from a production well was either re-injected to maintain pressure in the oil reservoir or vented (allowed to escape into the atmosphere) or flared (deliberately set on fire). Also at that time, the exploration activities of multinational oil companies such as EPMI (ESSO Production Malaysia Incorporated, now ExxonMobil), Royal Dutch Shell and Conoco Incorporated were primarily directed at discovering new oil fields. Since this was being done under a *concession* system, there was little interest in discovering new natural gas reservoirs.

The later signing of *production-sharing contracts* between PETRONAS, EPMI and Shell rectified this situation somewhat. The contracts emphasized “the need for good oil field practices” and resulted in the elimination of venting and flaring since the accompanying natural gas was now a marketable commodity. New gas utilization projects were undertaken with the establishment of LNG (liquefied natural gas) plants in Bintulu, Sarawak, and gas-processing plants in Kertih, Terengganu.

The STI opportunity connected with this scenario is the review of past exploration data and the acquisition of new information wherever possible. STI-based modelling and analysis using *extensive field data* can lead to the *re-evaluation* of now-defunct production fields.

The emerging STI opportunities in the oil and gas sub-sector may be summarised in Figure 6.4.

| Fuel | Category | STI Opportunities in the Energy Supply Side | STI Opportunities in the Energy Demand Side |
|---|---|---|---|
| Oil | Conventional Oil | • Develop small and marginal fields<br>• Rejuvenate mature fields using EOR techniques<br>• Continue deepwater exploration activities<br>• Further develop drilling and extraction technology | • Continue R&D to achieve higher fuel efficiency in internal combustion engines |
| | Non-conventional Oil | • Develop oil shale and peat deposits<br>• Develop tar sand deposits<br>• Develop heavy oil products | |
| Natural Gas | Conventional Natural Gas | • Develop small fields using the FLNG concept<br>• Review exploration data and re-evaluate old fields<br>• Develop new carbon capture and sequestration techniques | • Explore gas district cooling (GDC) systems<br>• CNG for NGVs<br>• Further develop techniques for re-gasification of LNG<br>• Develop a hydrogen-based fuel economy<br>• Explore the fuel cell concept |
| | Non-conventional Natural Gas | • Develop shale gas deposits<br>• Develop tight gas sand and acid gas deposits<br>• Develop coal-bed methane and coal-seam gas deposits | |

Figure 6.4: Emerging STI Opportunities in the Oil and Gas Sub-Sector

Source: Study Team

# COAL

Coal has always been considered the outcast of the energy-production industry, its "dirty fuel" image stemming in no small way from the soot, ash and toxic gases associated with its combustion. Ironically, however, it is coal that made the industrial powerhouses of the developed world what they are today by providing primary energy long before oil, natural gas and electricity were even heard of. Modern energy-production technology has, by some accounts, restored to coal the lofty position it once enjoyed in the energy supply-and-demand chain.

The current technologies employed for the combustion and use of coal as a source of heat energy in power generation and furnaces are subject to continual improvement by STI applications. These are (Figure 6.5):

- Pre-ignition pulverization in which the coal is crushed into a fine powder and mixed with pre-heated air so that combustion is instantaneous with minimal heat loss.
- Cyclone furnaces which can burn poorer grade coals with moisture and ash content of up to 25% in a centrifugal 'cyclone' motion of pre-heated air.
- Carbon capture and sequestration (CCS), also known as *carbon capture and storage*, in which the carbon dioxide resulting from combustion is 'captured' and stored in such a way that it does not enter the atmosphere.
- Integrated-gasification combined cycle (IGCC) which turns coal into synthetic gas (syngas).

| STI Opportunities in Energy Supply Side | STI Opportunities in Energy Demand Side | STI Opportunities in Malaysia |
|---|---|---|
| • Carbon capture and sequestration (CCS)<br>• Integrated-gasification combined cycle (IGCC)<br>• Ultra-supercritical (USC) Steam Generation<br>• Low carbon technologies | • Clean coal technologies for power generation<br>• Improving energy efficiencies in power generation<br>• Minimising energy losses | • Malaysia has relatively poor coal resources in Sarawak and has to import coal from Australia, Indonesia and South Africa. |

Figure 6.5: Emerging STI Opportunities for Coal

Source: Study Team

# BUILDINGS

## Energy Efficiency in Building Design

It is a feature of nature that a given source of energy can *never* be completely converted into a *desired* form of energy. The *useful energy* available from a given energy source is called exergy. This concept allows us to categorize energy sources in practical terms. The low-temperature waste heat from an air-conditioning unit is a low-exergy resource because it can be utilized only in a limited way, for example, to heat water in a home. On the other hand, natural gas is a high-exergy resource because several different useful applications such as electricity generation and the heating of entire buildings are possible. Most renewable energy resources are in the low-exergy category.

The building sub-sector, with its dominant share of annual energy usage, has very low exergy efficiency and continues to be responsible for environmental degradation. In the tropics, ventilation and air-conditioning (VAC) systems dominate the energy-consumption scene in buildings, with the latter demanding high-exergy sources. This means that existing air-conditioning devices are not compatible with renewable resources. In this respect, the design of exergy-efficient buildings using low-exergy equipment is vital to sustainable development. This is a difficult area in which to conduct R&D since it requires an in-depth understanding of the laws of thermodynamics which are very complex. The current lack of information and data on the subject represents a fantastic STI-related opportunity. Striving for energy-efficient products and services in the built and building industries will be the trend for the next 20 to 30 years.

Some products and systems with higher energy efficiency are already in the market. These include

- thermally-activated building components for floor-cooling systems;
- waterborne systems in which cooling pipes are placed into the concrete slabs used in construction; and
- airborne hollow-core deck systems using air circulating within the walls.

Further R&D is needed to explore other schemes for producing cooling effects in buildings. These might include

- using the relative coolness of the ground;
- using ground water, river water or sea water; and
- using radiation of heat waves into a clear night sky.

For the built industry, all efforts to harness solar energy to drive energy-efficient products are definitely tracking in the right direction. Innovations in this area have hitherto been limited to water heaters and solar thermal cooling. There is much more to be taken advantage of. Solar absorption cooling is an excellent prospect for tropical applications. The widespread use of low-energy cooling systems in buildings will tap extensively into renewable energy resources. Without this, the transition towards an energy-sustainable built environment will be delayed for decades.

## Solar Thermal Cooling

Chapter 2 explained the concept of *solar thermal cooling* (STC) using evacuated-tube collectors. Whilst residential roofs are freely available for photovoltaic cell panels and flat-plate collectors, the roofs of industrial and low-rise commercial buildings can be just as productive for solar air-conditioning applications using such collectors, as illustrated in Figure 6.6. Here is an STI opportunity that should be seized. To date, commercial activities to exploit the STC concept have attracted only a handful of SMEs.

Figure 6.6: An Array of Evacuated-Tube Collectors on the Roof of a Commercial Building

Source: www.builditsolar.com

## Co-generation Cooling-cum-Electricity System

An excellent energy-efficient product is a small co-generation system using LPG or LNG to produce cooling via an absorption cycle and then feeding the hydrogen by-product to a fuel cell to produce electricity which can be fed to the National Grid. Figure 6.7 shows a schematic for a related system that has been used in Japan since 2005. That same year, Ir. T.L. Chen (a member of the study team) suggested a system to produce cooling using the same concept. Such a system has yet to materialize.

Assuming 'clean-energy' natural gas continues to be available in Malaysia for the next 30 years or so, this system can command a substantial market with feasible applications in high-rise residential buildings, service apartments and hotels. The new trend of shoplot office buildings also constitutes a very suitable application. Additionally, the export potential of such products within this region as well as in the Middle East is very real.

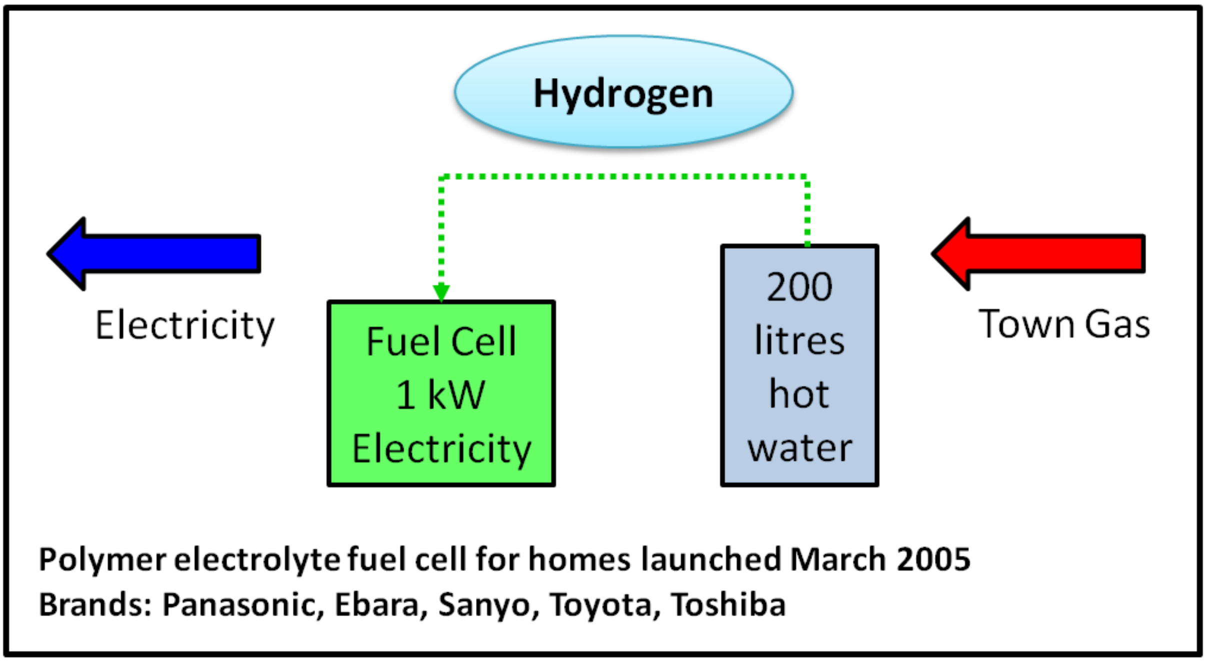


Figure 6.7: A Residential Fuel Cell Co-generation System

Source: Ir. TL Chen, 2000

## Air-Conditioning and Hydrocarbon Refrigerants

Up to 60% of the energy used in the commercial building sub-sector is consumed by air-conditioning. Hence, improving the efficiency of the refrigeration cycle that is central to all conventional air-conditioning systems will be far more effective than trying to deal with any other components of energy use in buildings.

Chlorofluorocarbons (CFCs) are, to date, the most efficient and effective refrigerants ever devised. Hence, their widespread use went unabated for more than half a century after their introduction in the 1930s. However, their colossal side effects on the ozone layer led to a ban on the use of them in 1995. The initial response of the industry was to switch to hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs). This was done in Malaysia at great expense. However, it is now known that the continual use of these substitutes, though not as deadly as CFCs, will also have long-term adverse effects on the ozone layer.

Enter the *hydrocarbon* (HC) refrigerant[32]. Hydrocarbons are natural and non-toxic substances, with zero ozone-depleting properties. In combination with ammonia, they had been used as refrigerants as early as 1867 but were abandoned some 60 years later with the

[32] Much of the following material on hydrocarbon refrigerants was derived from the website *www.hychill.com*.

advent of CFCs. While the technology of the early twentieth century did not favour their use, the story is quite a different one today. Extensive research conducted in a host of countries around the world clearly indicates that HC refrigerants

- can act as substitutes for HCFCs and HFCs;
- are safe to use provided proper handling procedures are observed;
- are almost as efficient as conventional refrigerants;
- are economical to produce since they can be derived from natural gas;
- are environmentally friendly; and
- can work just as well as conventional refrigerants without any change in compressor components.

On the international scene, HC refrigerants are making a comeback. This began in 1995 in Australia and has spread across Europe. Four out of five UK supermarket chains use hydrocarbons for air-conditioning their premises and refrigerating their quick-expiring stock while Germany has turned 100% to HCs. The Australians, meanwhile, plan to phase out all conventional refrigerants by 2015.

Figure 6.8 provides some vital scientific and engineering data to support the case for switching back to HC refrigerants.

| Refrigerant Industry Code | Description | Critical Temperature (°C) | Toxicity | | Auto Ignition Temperature (°C) | Atmospheric Life (years) | Environmental | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | LC50 (ppm) | Allowable Exposure Limit (ppm) | | | GWP 20/100 yr | ODP | COP |
| R11 | CGC-11 | 198.0 | 26,200 | 1,000 | > 750 | 55 | 5,000/4,000 | 1.0 | 5.01 |
| R123 | HCGC-123 | 183.7 | 32,000 | 10 to 30 | 730 | 2 | 300/100 | 0.02 | 4.93 |
| R12 | CFC-12 | 111.8 | 800,000 | 1,000 | > 750 | 130 | 7,900/8,500 | 0.9 | 4.71 |
| R22 | HCFC-22 | 96.2 | 220,000 | 1,000 | 632 | 16 | 4,300/1,700 | 0.055 | 4.64 |
| R134a | HFC-134a | 101.1 | 567,000 | 1,000 | 743 | 16 | 3,300/1,300 | 0 | 4.63 |
| R404a | HFC-125, HFC-134a, HFC-143a | 72.1 | 500,000 | 1,000 | 728 | > 16 | 5,000/3,700 | 0 | 4.22 |
| R407C | HFC-32, HFC-125, HFC-134a | 87.3 | - | 1,000 | 704 | > 16 | 3,400/1,600 | 0 | 4.47 |
| R290 | HC-290 | 125.3 | - | 1,000 | 450 | < 1 | 3/3 | 0 | 4.80 |
| R600a | HC-600a | 135.0 | 520,000 | 800 | 530 | < 1 | 3/3 | 0 | 4.80 |

Figure 6.8: Physical Properties of Selected Refrigerants

Source: Ir. TL Chen, 2000. (Note: LC = lethal concentration; GWP = global warming potential; ODP = ozone depletion potential; COP = coefficient of performance; ppm = parts per million)

In the late 1990s, a number of tests using a variety of HC refrigerants were carried out by an engineering-consultant firm in collaboration with our national carmaker and a manufacturer of automobile air-conditioning units[33]. While the tests were not exhaustive enough to produce conclusive results, they quite clearly indicated that HC refrigerants

- appear to be compatible with the air-conditioning hardware commonly being used in Malaysia;
- can replace the bulk of common refrigerants in use;
- are nearly as energy-efficient as conventional substances; and
- are able to reduce running costs by at least 10%.

Hence, on the local front, it is clear

- that there is a huge market for HC refrigerants;
- that HC refrigerants will be inexpensive since they can be produced from 100% local raw materials, mainly natural gas; and
- that HC refrigerants will contribute to savings in monetary terms.

In the figures that follow, broad estimates of potential energy savings that could be made by switching to HC refrigerants in three major areas of electricity consumption are presented.

[33] A reference to these tests is made in Appendix 7.1.

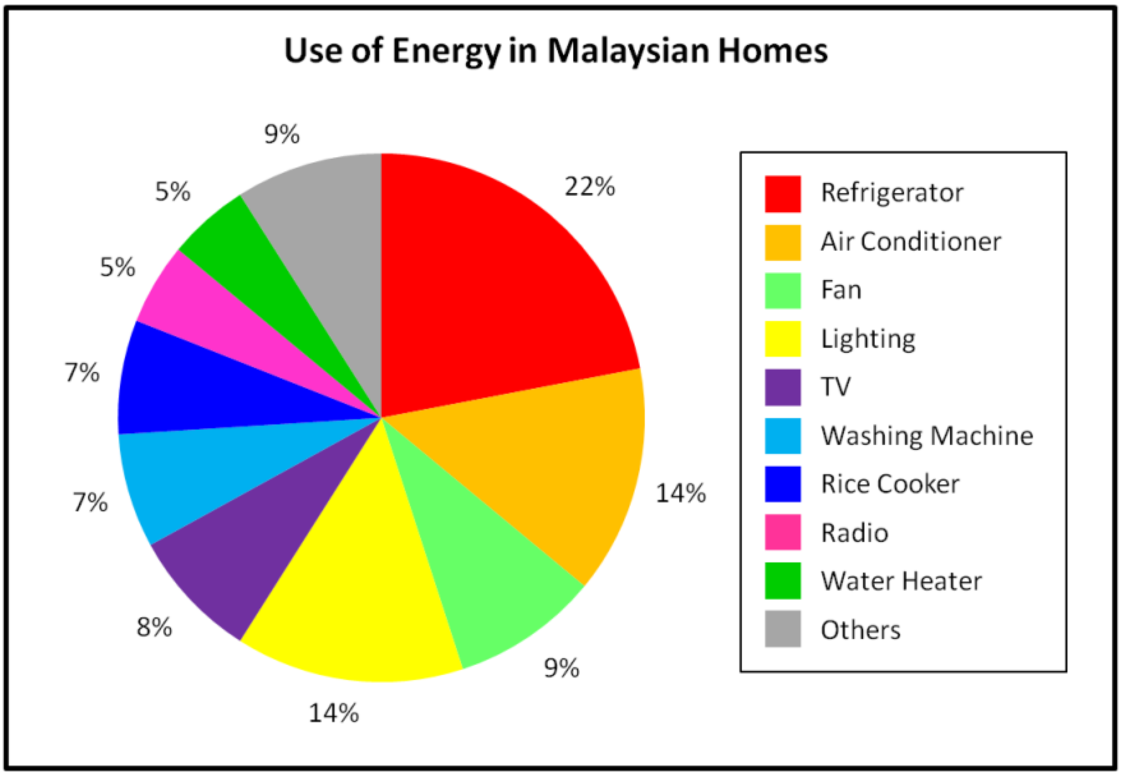


**Figure 6.9: Residential Air-conditioning and Refrigeration, 2008**

Source: Faridah Taha, UTM

(1) Total residential consumption of electricity = 16,000 GWh

(2) Percentage of total consumption due to air-conditioning and refrigeration = 36% *

(3) 36% of 16,000 GWh = 5,760 GWh

(4) Assume that the air-conditioning and refrigeration units are responsible for 33% of the total electricity consumed (a conservative figure)

(5) 33% of 5760 GWh = 1900 GWh

(6) Assume that a hydrocarbon refrigerant is 10% more energy-efficient than a conventional refrigerant

(7) Electrical energy saved = 190 GWh

* A 2005 report by the Malaysian-Danish Environmental Cooperation Programme puts this figure at 54%.

(1) Total consumption of electricity in commercial buildings = 26,800 GWh.

(2) Assume that 50% of such premises are air-conditioned

(3) Assume that air-conditioning units are responsible for 40% of the total electricity consumed

(4) Assume that the compressors alone are responsible for 25% of this total

(5) 25% of 40% of 50% of 26,800 GWh = 1340 GWh

(6) Assume that a hydrocarbon refrigerant is 10% more energy-efficient than a conventional refrigerant

(7) Electrical energy saved = 134 GWh

**Figure 6.10: Air-conditioning in Commercial Buildings, 2008**

(1) Total consumption of electricity in the industrial sub-sector = 35,000 GWh

(2) Assume that 5% of this electricity is consumed for air-conditioning and refrigeration (a conservative figure)

(3) Assume that the compressors alone are responsible for 25% of this total

(4) 25% of 5% of 35,000 GWh = 438 GWh

(5) Assume that a hydrocarbon refrigerant is 10% more energy-efficient than a conventional refrigerant

(6) Electrical energy saved = 44 GWh

**Figure 6.11: Industrial Air-Conditioning and Refrigeration, 2008**

The overall energy-saving benefit that can be derived from switching to HC refrigerants in air-conditioning and refrigeration in the residential, commercial and industrial sub-sectors is summarised as follows:

- Total energy consumption = 16,000 + 26,800 + 35,000 = 77,800 GWh
- Total energy savings = 190 + 134 + 44 = 368 GWh
- Total percentage savings = (368 ÷ 77,800) x 100 = 0.5%

It is obvious that there is a considerable measure of over-simplification in arriving at the final figures for the three sub-sectors. However, it should also be borne in mind that the assumptions made represent worst-case scenarios which render each final estimate a highly conservative one. In other words, the 0.5% overall saving is the minimum figure that can be expected with the suggested switch. If one adds to this the potential savings in fuel if the switch is extended to air-conditioning units in all vehicles, it becomes abundantly clear that the suggestion to substitute conventional refrigerants with hydrocarbons merits urgent support and consideration. The exercise of obtaining raw data nationwide to confirm the veracity of the claim is in itself a tremendous STI-related opportunity.

# TRANSPORTATION

The consumption of energy in the transportation sub-sector can be drastically reduced in the next one or two decades by two broad measures. These are:

- the aggressive application of STI knowledge and R&D in every scientific dimension possible to increase the overall efficiency of automobiles; and
- the improvement and overhauling of the national public transport system by means of innovative schemes, the issuance of appropriate regulations, and enforcing compliance with these.

This is not a new approach but an application of common sense and ordinary wisdom that is prevalent in most parts of the developed world. We cannot afford to lag too far behind. The paragraphs that follow provide some insight into the first of these two measures. Chapter 9 will deal with the second.

## Improving the Fuel Efficiency of Engines

It is not surprising to note that Malaysians generally give scant regard to the fuel economy of their vehicles since the prices of petrol and diesel in this country are relatively low**.** Most people are totally unaware of the fact that no more than 30% of the fuel consumed by an automobile engine is used to move the vehicle forward while the remaining 70% is wasted and lost to the surroundings in the form of heat. With the ever- rising cost of fuel in the face of depleting supplies, *raising the fuel efficiency of internal combustion engines* represents a huge STI research opportunity that is certain to bear fruit in due time. Increasing the distance a vehicle can travel per unit of fuel consumed must continue to be a primary concern of everyone everywhere.

Considerable effort is being made in this direction the world over. The improved fuel injector developed by the US Physics Professor, Ronggila Tao, holds the promise of greater efficiency, cleaner combustion and better mileage for American-made vehicles. *Similar breakthroughs are possible here.*

The STI opportunities available in this connection include

- further improvements in the design of the internal combustion engine based on the laws of thermodynamics – this is, admittedly, a very difficult area;
- reduction in vehicle weight whilst maintaining optimum size through re-designing of cabin and chassis and the use of new materials.

## Electric Vehicles

In the long term, the way forward is a complete ban on liquid-fuel-driven vehicles in urban centres and suburban areas. Since the only viable substitute for the ubiquitous internal combustion engine is the electric motor, it follows that electric vehicles are destined to dominate the transport scene in our fossil-fuel-uncertain future. While electric motors have been around for well over a hundred years, they represent a huge STI knowledge-building opportunity that literally knows no bounds.

At the same time, the government should initiate plans for developing the infrastructure necessary to support the extensive use of electric cars. A fundamental feature of such infrastructure would be public recharging facilities. City councils and municipalities must make it easy for TNB and other new start-up enterprises to install street-level recharging points and develop 'smart' power grids to supply the electric fleet without requiring extra generating capacity. A novel scheme is *"time of use" electric-power metering* which offers lower tariffs for off-peak consumption – this will make night-time recharging of batteries the preferred mode. If daytime recharging of batteries is going to occur on a large scale, the surge in demand will necessitate improvements in the National Grid and increases in *peak-time* generating capacity.

A long-term R&D programme will be required to develop all of the above. The exciting STI opportunities that already exist in this connection need to be accorded top-priority status by the government, electric utility companies and research institutions.

## Hybrid Vehicles

Hybrid vehicles are those with two sources of power – a standard internal combustion engine and an electric motor that draws power from a large battery. Plug-in hybrid electric vehicles (PHEVs), which charge their batteries from the National Grid, could reduce gasoline consumption significantly.  However, plug-in hybrids require more efficient and durable batteries which are able to withstand *deep* discharges. Such batteries are not yet in commercial large-scale production so an aggressive R&D programme to better understand the science of electrode potentials and their link to materials will result in a large payoff in due time. Given the technical difficulties faced in developing these batteries, it cannot be assumed that the PHEV will replace the standard automobile at an affordable price in the immediate future. Nonetheless, no effort must be spared in this direction.

## Improved Bio-Fuels

Petrol, diesel and kerosene together account for about 95% of the fuels used in the transportation sector. This characteristic of petroleum-based products dominating the use of energy in vehicles is prevalent worldwide. Brazil is the only country that has substantially switched to an alternative – ethanol[34]. The use of ethanol and bio-diesel blends as alternatives to conventional fuels suffers from many issues. Pre-eminent amongst these is the trade-off between the utilization of agricultural land for food or for fuel.

[34] Ethanol is the alcohol that is present in intoxicating beverages.

‘Second-generation’ bio-fuels are now being developed from a wider range of feedstock. The present focus is on making the best use of the whole plant instead of discarding the ‘fractions’ of biomass that were previously thought to be worthless. This is an important area that the country needs to exploit through research since we have abundant biomass resources. We should also seriously study the feasibility and commercial viability of producing fuel additives from biomass. Bio-MTBE (methyl-tertiary-butyl-ether) produced from bio-methanol and Bio-ETBE (ethyl-tertiary-butyl-ether) produced from bio-ethanol hold strong promise as additives to increase the octane rating of petrol and to reduce ‘knocking’.

## Hydrogen, the Alternative Fuel

The use of hydrogen as a fuel in the transportation sector represents a major STI opportunity which can become an investment in the country’s energy future. A transition to hydrogen as a major fuel in the next 50 years could fundamentally transform the Malaysian energy delivery system. This is because

- hydrogen can easily be produced by a number of inexpensive and environmentally-benign methods;
- the zero carbon dioxide emission from the use of hydrogen has zero impact on the environment; and
- hydrogen can be sourced from water which is available everywhere, thus guaranteeing energy security.

Hydrogen fuel cells (see Chapter 3) are devices that use the world’s lightest gas to produce electricity. The electrical output of such cells is currently very small and grossly insufficient for large-power applications such as motors to drive vehicles. It is expected that extensive R&D efforts in this field will result in fundamental breakthroughs. These will then feed STI opportunities that can be commercialized in fuel-cell vehicles (FCVs) in the medium term.

The FCV is a now a conceptual reality that is unlikely to become more than a niche product unless several challenges are overcome. These are

- the durability and cost of fuel cell materials, including their catalysts;
- the safe and cost-effective onboard storage of hydrogen;
- large-scale hydrogen production technologies;
- the storage, distribution and dispensing of hydrogen to end users; and
- the development of suitable hydrogen-refuelling infrastructure.

## Automobile Air-conditioning Refrigerants

Earlier in this chapter, the scientific basis for switching from HFC to HC refrigerants was presented in no uncertain terms. Some conservative estimates were made for the saving of electricity in the residential, commercial and industrial sub-sectors. Figure 6.12 carries a similar convincing argument on how the country can save *at least* 100 million litres of liquid fuel annually by using HC refrigerants in automobile air-conditioners. There is a need for more comprehensive data in support of this position. The immediate STI opportunity here is analogous to “low-hanging fruit that is ripe for the taking”.

(1) Number of vehicles on Malaysian roads = 17,000,000 (projection based on 2003 JPJ figures and yearly increments available from the website, *wolframalpha.com*)

(2) Private cars as a percentage of the total = 43% (based on 2003 JPJ figures)

(3) Percentage of private cars with air-conditioners = 95% (observational estimate)

(4) Number of air-conditioned vehicles on the road = 95% of 43% of 17,000,000 = 6,900,000

(5) Assume fuel consumption of 10 km per litre and that each vehicle logs in an average of 20,000 km per year, then total fuel consumption = 2,000 x 6,900,000 = 13.8 billion litres per year

(6) Assume the air-conditioning system is powered by 10% of this fuel, and that the compressors account for 80% of this. Then fuel consumption due to the compressors = 80% of 10% of 13.8 billion litres = 1,104 million litres of fuel per year

(7) Replacing HFC 134a with HC as refrigerant will improve operating efficiency of the air-conditioning system by 10%

(8) Therefore, total potential fuel savings = 110 million litres of fuel per year

**Figure 6.12: Automobile Air-Conditioning, 2010**

# RENEWABLE ENERGY

Renewable energy (RE) resources have a tremendous potential to provide sustained energy supplies for the future. As such, the nation should capitalize upon this hitherto untapped STI opportunity and leverage it to enhance energy security, sustainable development and economic prosperity for the country. Extensive efforts must be made to develop reliable, efficient and affordable RE-based technologies so that this ‘fifth’ member of the national fuel mix can become the *mainstay* of the power-generation and energy-supply industries.

Figure 6.13 highlights some of the emerging STI opportunities in the RE sub-sector. The inclusion of hydropower under the RE category warrants a note of explanation. Clearly, hydroelectricity *is renewable energy* in the sense that rivers will always continue to flow, barring any major climatic changes in a given region of the world. However, the number of commercially viable hydroelectric sites is limited by virtue of the geography of a region, not to mention the environmental impact of flooding a river basin. It is in *this context* that hydroelectric power is non-renewable and therefore unsustainable.

Figure 6.14 depicts, in broad conceptual terms, the forging of collaboration between the current technologies that are designed to exploit non-renewable resources and the emerging technologies that are committed to the development of RE. At a glance, these technologies seem mutually exclusive. A *mutually inclusive* and synergistic approach is obviously the way to go if the hitherto elusive goal of true sustainable development is to be achieved.

| Fuel | STI Opportunities in Energy Supply Side | STI Opportunities in Energy Demand Side | Comments |
|---|---|---|---|
| **Hydro** | • Mini-hydro systems | • Zero-emission buildings<br>• Solar water-heating<br>• Development of deep-discharge batteries<br>• Smart homes, smart cities and smart grids<br>• Decarbonising the transportation sector<br>• 'Flex' fuels<br>• Hybrid vehicles<br>• Green technology<br>• Key technologies for interfacing with the national grid e.g. inverters and storage devices | • Malaysia has hydro-power potential of 24,000 MW capacity |
| **Solar** | • Solar photovoltaics (PV)<br>• Concentrating solar power (CSP) technologies | | • Solar water-heating systems are well developed<br>• Cost reduction of PV devices |
| **Wind** | • Onshore and offshore winds | | • Wind speeds are relatively slow to justify development of large wind turbines. |
| **Geothermal** | • Super-heated steam | | • Malaysia can develop its geothermal resource in Tawau, Sabah.<br>• Additional "spin-off" source of tourism revenue through establishment of hotel/gold industry |
| **Biomass/ Biofuel** | • Palm-oil diesel<br>• Biofuels from municipal wastes, etc.<br>• Second-generation biofuels | | • Reduce cost of power generation from biomass |
| **Ocean** | • Tidal Energy<br>• Wave Energy<br>• Ocean Thermal Energy Conversion (OTEC) Development (Sabah Trough) | New potential source of renewable energy | • Sabah Trough (at depth of 2,900m, temp. is $3^0$. By pumping 1000 cubic metres/sec of the bottom cold sea water to the surface, the energy potential would be about 2500 MW, larger than the biggest coal-fired power plant of TNB Janamanjung of 2100 MW) |

Figure 6.13: Emerging Opportunities in Renewable Energy

Source: Study Team

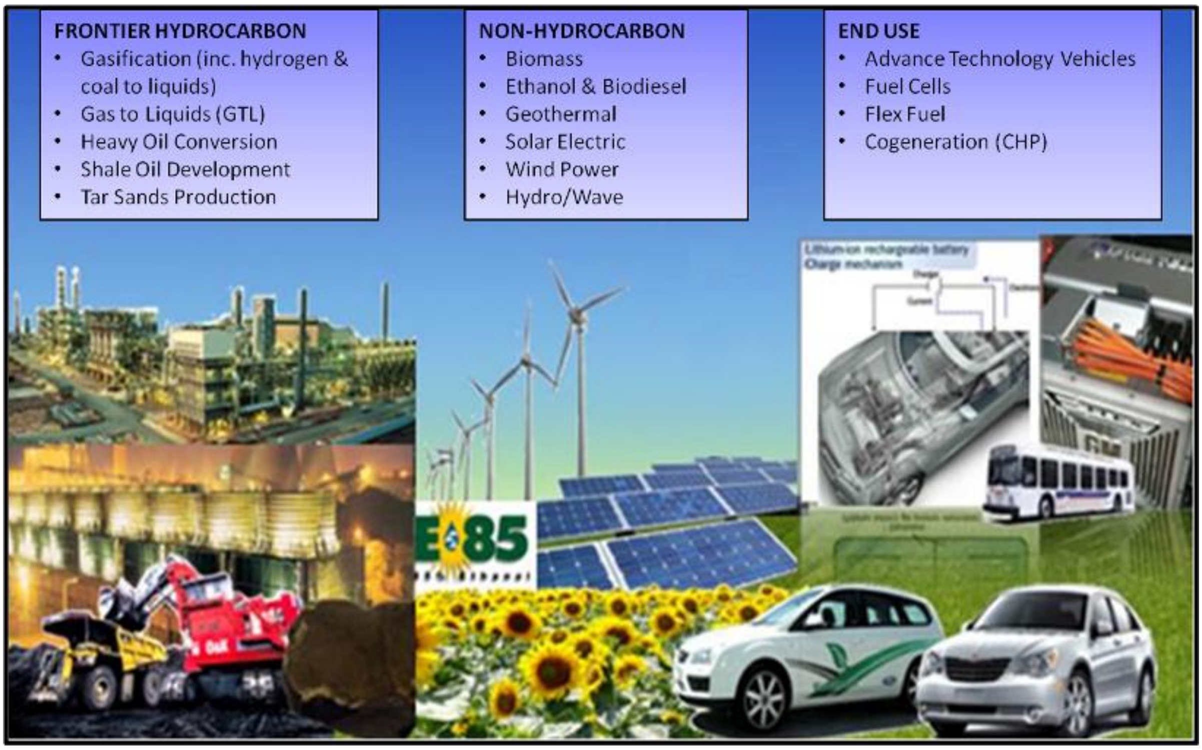


Figure 6.14: Technological Collaboration for Sustainable Development

Source: Corporate Information & Research Unit (CIRU), PETRONAS

## Energy from Biomass

As a major producer of agricultural commodities in the region, Malaysia is well positioned amongst the ASEAN countries to promote the use of biomass as a renewable energy resource in her national energy mix, as shown in Figure 6.15. The country's SREP Programme[35] provides the institutional driver that will direct the exploitation of our vast biomass-for-energy potential.

[35] Small renewable energy power programme

| Sector | Quantity, kilotonnes per year | Electrical Power Potential, MW | Annual Electrical Energy Potential, GWh |
|---|---|---|---|
| EFB [36] | **16,700** | **2,100** | **18,400** |
| POME [37] | **38,900** | **320** | **2,800** |
| Wood Chips | **2,200** | **70** | **600** |
| Rice Husks | **400** | **30** | **300** |
| Bagasse [38] | **300** | **25** | **200** |
| TOTAL | **58,500** | **2,545** | **22,300** |

Figure 6.15: Biomass Potential for Power Generation in Malaysia

Source: "Challenges in the Small Renewable Energy Power (SREP) Programme," Energy Commission, August 2007. Presented at the PTM RE Roadshow.

Current STI applications include:

- Grate combustion;
- Fluidized bed combustion (FBC) which suspends solid fuels on upwardly-directed jets of air during the combustion process; and
- Circulating fluidized bed combustion (CFBC), as illustrated in Figure 6.16, in which fine particles of partly-burnt coal, ash and bed (waste) material are carried along with the flue gases to the upper areas of a furnace and then into a cyclone.

[36] EFB: empty fruit bunches (after removal of oil palm fruits)
[37] POME: palm oil mill effluents
[38] Bagasse is the fibrous residue from sugarcane after the extraction of the juice.

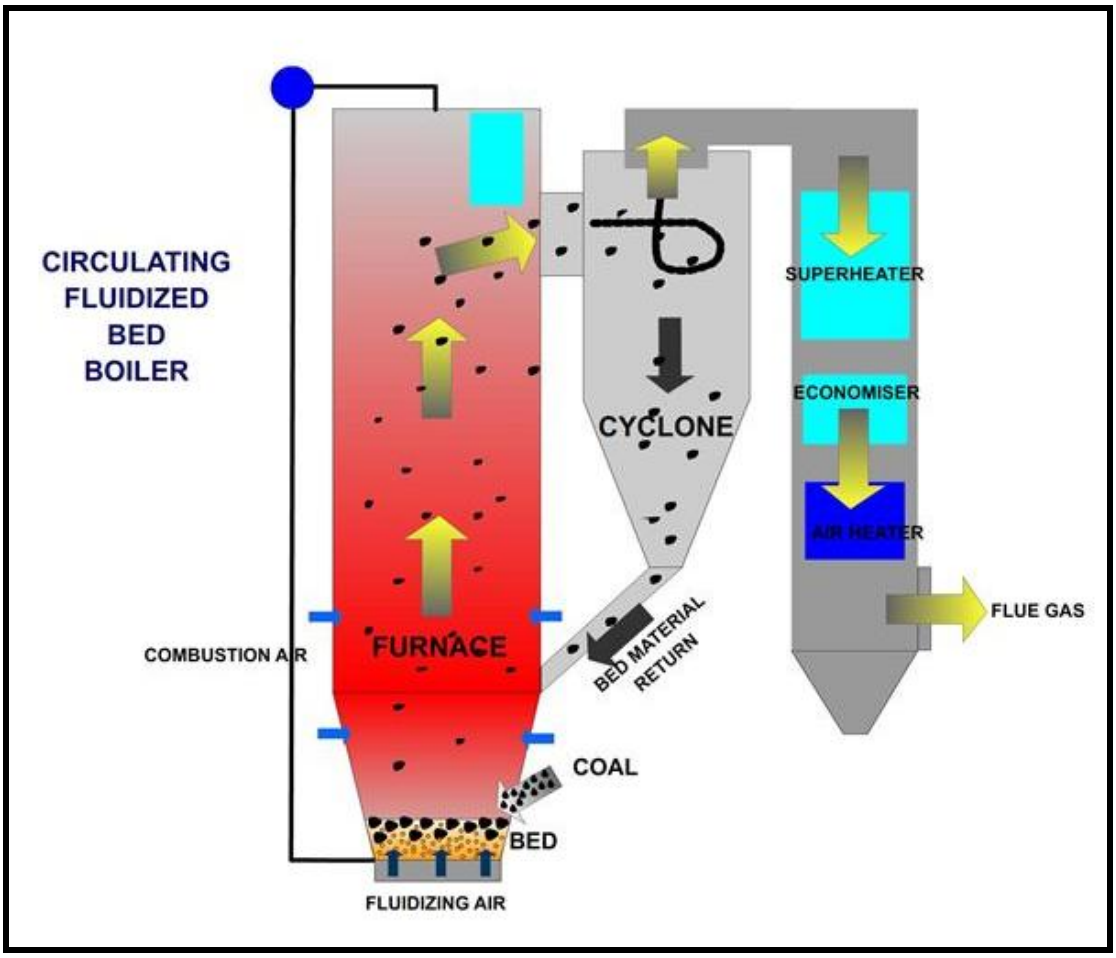


Figure 6.16: A CFBC System for the Combustion of Biomass

Source: www.brighthub.com

The generation of hydrogen from biomass-based compounds is an emerging technology. It is also a starting point for biomass-to-liquid (BTL) fuel which is being contemplated for the transportation sub-sector. Low-temperature fuel cells using hydrogen have also evolved while the high-temperature versions are in transition towards commercialization. The syngas (carbon monoxide and hydrogen) generated using thermo-chemical conversion is an ideal raw material for the construction of solid-oxide fuel cells.

Clear development areas are the production of higher quality bio-fuels with an acceptable shelf life and cleaner combustion properties. These fuels must also be usable in existing fossil-fuel devices with minimum adaptation. For example, Australia and Japan are addressing bio-fuel productivity using algae as a source of raw material and this is being researched extensively in various countries.

The following sub-treatises address some priorities in RE development and a possible STI-related development agenda for the Asia-Pacific region during the period 2010 to 2050. These accounts are extracted and paraphrased from the document titled "Science Plan on Sustainable Energy" authored by the International Council for Science. The document is reproduced in full in Appendix 7.2.

## Wind Energy

The renewable resource of wind energy is currently attracting widespread interest around the world with implementation already underway in several countries. This is mainly due to aggressive R&D efforts finding fruition in improved performance and reduced costs. Continuing innovation in design and materials holds out the promise of a further 50% reduction in costs by 2020 augmented by even better performance. It is clear that if the present trend continues, wind energy will be able to compete with conventional energy sources in the power-generation sub-sector in the medium term.

State-of-the-art wind technology boasts single turbines capable of a 2 MW output. Putting these into *continuous commercial operation* will require an in-depth understanding of

- tensile and shear loads as the blades are stretched and twisted at high speeds;
- the response of the blades and the supporting structure to inertial constraints, especially during start-up;
- patterns of airflow as well as uncertainties in the incident wind field; and
- new materials that can withstand wear and tear due to stress cycles and extreme weather conditions.

The above factors provide extensive STI research opportunities in terms of creating new knowledge drawn from laboratory-based investigations as well as observations out in the open. Associated research activities can be directed towards

- developing more sophisticated control systems;
- integrating wind turbines into existing energy supply systems;
- using wind turbines in combination with other energy-storage devices such as hydrogen fuel cells;
- integrating large 500 MW wind farms into extensive distribution networks such as the National Grid;
- exploring offshore opportunities where winds are generally stronger;
- developing condition-monitoring devices and sensors to detect incipient faults in the mechanical drive train (gearboxes) and generators;
- modeling large-scale grid-integration parameters such as load variations and fault conditions;
- developing laboratories for dynamic testing of large components; and
- mapping of wind fields by collecting data and generating wind-potential statistics (possibly a two-year effort).

## Solar Photovoltaic (PV) Devices

Significant advances in wafer-cell technology are being made in all of the following areas:

- front and rear contact formation with localized dopants;
- use of laser and inkjet printers to define and form features;
- localized incorporation of dopant impurities;
- shifting of front contacts to the rear; and
- use of n-type doped wafers and thinner wafers.

Two thin-film photovoltaic technologies based on cadmium telluride and copper-indium diselenide are emerging while a number of research groups are actively developing new thin-film crystalline silicon devices. Meanwhile, amorphous silicon is starting to be used in conjunction with crystalline silicon wafers.

Expensive but high-efficiency multi-junction photovoltaics made from compound semiconductors are being used in terrestrial concentrators.
Such photovoltaic concentrators are becoming increasingly available. The conversion efficiency increases with light intensity as long as the temperature is not allowed to increase significantly.

All of the above represent just some of the STI-related opportunities connected with solar photovoltaic devices. And the end is nowhere in sight!

## Solar Thermal Energy

The heating of air is an obvious ‘non-starter’ in the Malaysian domestic context. However, a copious flow of warm or hot air is necessary in many industrial processes. The science of air heaters is more complex than that of water heaters due to the lower density, specific heat capacity and thermal conductivity of air relative to water. Methods used to enhance heat transfer to the air tend to increase the pressure drop across the solar collector thereby requiring additional fan power. One low-cost air heater design uses a perforated, unglazed collector plate with a rear duct maintained at negative pressure.

Decades of research have been poured into devices to combine photovoltaics and thermal-energy collectors so as to achieve the cooling of the former (thus improving its efficiency) and dual outputs of electricity and heat. Both air and liquids have been used as thermal transfer media. In one specific case, hot air is collected from ventilated building façades. Such systems are in the very early stages of development and a significant research gap has to be bridged before widespread adoption can be feasible.

Fossil fuels provide a “base load availability” which no form of renewable energy can match. Because of this, integrated thermal storage is a keenly researched concept that aims to ‘rival’ fossil fuels in this area. Molten salt (with sodium nitrate and potassium nitrate) is currently the best heat-transfer fluid and energy-storage medium in this connection.

Opportunities for STI applications and R&D covering both solar photovoltaic and solar thermal energy include:

- reducing costs in manufacturing and mass production;
- investigating the use of the blue (more highly energetic) end of the visible spectrum;
- developing third-generation silicon cells;
- synthesizing new materials;
- designing better reflectors and concentrators;
- optimizing the action of work fluids and thermal storage media;
- developing coating material for solar thermal installations; and
- designing better heliostats (devices that track the sun).

## Geothermal Energy

Malaysia has no geothermal energy resources worth developing. However, the country is surrounded by neighbours that have rich untapped geothermal fields. STI applications in this area would thus focus on making us an industry leader in the region, offering expertise to our neighbours for the exploration and utilization of *their* vast geothermal resources. Such opportunities would include:

- resource mapping and exploration to identify geothermal fields;
- assessment of conventional geothermal systems;
- drilling, production and distribution technologies;
- developing reservoir-management know-how; and
- designing geothermal heat pumps for various heating applications.

## Hydroelectric Power

A large-scale hydroelectric power plant, as a major contributor to the National Grid, needs to be stable and reliable. But it 'suffers' from a conflict of interest, so to speak, when the water stored behind the dam is needed for agricultural purposes during dry seasons. Therefore, the management of water continues to be the fundamental challenge at all hydroelectric projects, whether major or minor, since non-power uses of water (such as irrigation) naturally compete with power generation.

Other challenges faced at hydroelectric power stations include:

- The withdrawal of water from the reservoir for public supply, aquaculture, mining, industries and thermal-based power generation;

- The removal of silt from sluice gates, penstocks and turbines;
- Attaining higher efficiencies for turbines and generators;
- Ongoing environmental impact studies (EIAs) even after the dam and power station have been commissioned;
- Improving the efficiency and lifetime of all component structures; and
- Reducing maintenance and operational costs.

Given the challenges outlined above, the importance of STI-based solutions to support cost-effective decision-making is critical. Further research in water management, civil work, materials design and distribution systems will speed development.

### Waste-to-Energy Schemes

Waste-to-energy (WTE) technologies are complex and capital intensive, and they require strong technical support in the form of specific human resource needs. The present diversity of the techniques employed to convert waste into fuel necessitates specific-case analyses in order to develop appropriate management guidelines.

The potential *thermochemical* areas for R&D are:

- Plasma-arc gasification which breaks down waste material at high temperatures;
- Pyrolysis and gasification, two related forms of thermal treatment in which waste materials are heated in a limited-oxygen environment to convert them into a more combustible form; and
- RDF (refuse-derived fuel) operations in which waste is converted into combustible pellets by shredding and dehydrating.

The potential *biochemical* areas for development include systems involving bio-cells, landfill-gas extraction and bio-gas reactor configurations. There is ongoing work in microbial fuel cells which are bio-electrochemical systems that generate electricity by mimicking bacterial interactions found in nature.

### Ocean Energy

STI applications with respect to ocean energy include:

- resource-mapping for OTEC[39], wave energy and tidal energy potentials (a necessary first step);

[39] Ocean thermal energy conversion

- reduction in cost of OTEC installations through the use of more efficient heat exchangers, improved interface between floating barges and cold water pipes, better floating platforms and stronger mooring devices;
- more aggressive R&D on shoreline wave-energy devices such as the Salter ‘duck’, detailed studies on the dynamics of breaking waves, analyses of corrosion and wear on mechanical parts exposed to wave action in offshore devices;
- reduction in cost of barrage-based tidal power plants through deployment of prefabricated caissons, capture of large tidal power through the use of high-efficiency turbines; and
- improving the economics of ocean energy sources through the development of value-added by-products such as fresh water and aquaculture.

# NUCLEAR

Figure 6.17 represents the STI opportunities that exist in the area of nuclear power. The country’s foray into this prohibitively expensive and still controversial arena is indicative of the energy concern on the part of the government.

| STI Opportunities in Energy Supply Side | STI Opportunities in Energy Demand Side | STI Opportunities in Malaysia |
|---|---|---|
| • Sustainable nuclear fission and fusion<br>• Fourth generation nuclear reactors | | • Nuclear power to be developed beyond 2020 but human capital needs to be developed much earlier. |

Figure 6.17: STI and the Nuclear Power Industry

Source: Study Team

Recommendations on the development and utilization of nuclear power in the country are dealt with in Chapter 9.

# CHAPTER SEVEN

# International 'Best Practices' and Country Models

Many developing countries have already attached a heightened importance to having a robust STI resource base. They have also successfully institutionalized the procedures and processes necessary to maintain and expand this base. In addition to this, the concept of sustainability is typically taking centre stage in most national development plans, policies and processes.

Common wisdom dictates that the energy question must occupy a strategic position in all these growth activities, and that the development of STI resources and capacity must have a profile commensurate with this.

In this chapter, the reader will be exposed to some of the emerging views on the concept of sustainable development (SD). Some of these views have formed the substance of discussions at the international level while others have been promulgated by agencies renowned for more progressive thinking on the subject. Some snapshots of successful SD planning activities around the globe will follow. Since the examples are drawn from both developing and developed countries, we would have the privilege of 'window shopping' with the option of 'buying' whatever we deem suitable to help formulate the SD planning processes so vital to continued economic growth in this country.

The study team recommends that all the parties involved in formulating plans as well as those responsible for implementing them should be required to read all or most of the documents cited. This is because these documents constitute an excellent learning aid that would bring fresh insight to the planning processes and strengthen the implementation of each plan so that our development activities as a nation will see higher levels of focus, coverage, efficiency and completeness.

## International Standards

The adoption of international standards[40] plays a critical role in the path to development for any nation. Associated with the acceptance of such standards on just about any area pertaining to modern life is the availability of a portfolio of documents that can guide a nation's development efforts. This is as true in the area of energy utilization as it is in any

[40] The reader who is interested in a full treatise on this subject is directed to the ISO Focus Magazine, Special Issue, November 2007, available at http://www.iso.org/iso/iso_focus_wec_special.pdf

other area of growth. By acquiescing to the standards that have been set by more advanced countries, we can leapfrog many of the pitfalls that these developed nations had fallen into along the route forward. Thus should all aspects of energy production and consumption in the country be rigorously evaluated in the light of what is internationally acceptable. Then, wherever and whenever we are found lacking, we must summon the political will necessary to bring about conformity to the norms that exist in Western countries. It seems perfectly right to do whatever it takes to ensure that everything Malaysia does in all its endeavours is totally consistent with international thinking on the subject of sustainable development.

## The World Bank Forum, Washington D.C., 2007 [41]

The organizers of this event in the US capital published a discussion paper titled "Building Science, Technology and Innovation Capacity for Sustainable Growth and Poverty Reduction" prior to the forum. The purpose of the paper was to stimulate discussion at the forum proper. In reviewing the paper, the study team reached a consensus that the ideas, approaches and definitions employed would prove extremely useful in the context of deepening and broadening the Malaysian STI resource base.

The paper attempted to focus the attention of would-be participants at the forum on the middle-income countries of the world. Such countries, which face increasing competitive pressure from each other, need to (1) balance the desire to build R&D capacity against the tendency to acquire knowledge from without, (2) focus on upgrading technology, and (3) generate more value from their *natural* resource bases. As such, *the setting of priorities* to determine the most cost-effective sequence of initiatives for STI capacity building would be the endeavour of paramount importance.

The principal objectives of the forum were:

- To understand the STI capacity building processes that were already underway around the world;
- To share lessons and experiences in STI capacity building;
- To identify the reasons why some capacity-building programmes were successful and others were not; and
- To build government capability for STI-related policy making.

The expected outcomes of the forum were:

- To identify specific ideas, strategies and policies for improving STI capacity-

[41] The following discussion, which revolves around the World Bank Forum, puts together information taken from two sources:
(1) The discussion paper titled "Building Science, Technology and Innovation Capacity for Sustainable Growth and Poverty Reduction", reproduced in full in Appendix 8.1; and
(2) "Science, Technology, and Innovation: Capacity Building for Sustainable Growth and Poverty Reduction" by editors Alfred Watkins and Michael Ehst, available from:
http://siteresources.worldbank.org/EDUCATION/Resources/278200-1099079877269/547664-1099079975330/DID_STI_Capacity_Building.pdf

building programmes; and

- To publish a flagship report on STI capacity building for sustainable development.

Quite rightly, the paper has raised some fundamental questions regarding STI capacity building. The following discussion summarizes some of the more important issues pertaining to the topic.

The paper suggests that STI capacity building involves two *types* of capacity in four distinct *dimensions*.

## Types of STI Capacity

### *(1) The capacity to acquire and use existing knowledge*

A middle-income country should *acquire* existing knowledge produced outside its own borders, *adapt* it for local use, then *diffuse* and *adopt* it on a nation-wide basis. This is the most sensible and cost-effective approach to capacity building for a very obvious reason: despite any dramatic increase in the size and quality of the national research effort, the entire R&D output of any single country will be a small fraction of the global one. So, if a country is to grow and prosper, most of the knowledge that it utilizes should be that which it derives from without.

Developing the *capacity* to *seek and identify* this existing knowledge is thus an indispensable component of STI capacity building. While physical facilities such as information and communications technology (ICT), better internet connections and larger bandwidth are needed to tap into this pool of global knowledge, the development of this capacity is actually much more complex and difficult than it seems. Thus did the forum seek to make the *understanding* of this particular challenge and the *techniques employed* to overcome it a major theme.

### *(2) The capacity to produce and use new knowledge*

This entails the capacity to conduct high-level basic research, either alone or in partnership with leading global R&D institutions. While it is true that not every country has the wherewithal or even the need to participate in the global R&D effort in specific areas (e.g. to discover a cure for AIDS or to develop an anti-malarial vaccine), each one still needs to find novel or innovative ways of applying modern science to solving local problems.

## Dimensions of STI Capacity Building

### *(1) Government policy making*

Governments must be able to formulate coherent STI policies and link them to discrete development strategies. Such policies are both explicit (e.g. grant programmes to finance R&D and link it to industry needs) and implicit (e.g. trade policies protecting domestic producers from global competition but discouraging innovation). While many transition economies have a well developed or even world-class scientific infrastructure, the absence of a suitable enabling environment often prevents them from converting this capacity into knowledge-intensive, value-added goods and services. The key point is that every country needs to identify those areas in which its *national innovation system* (if, at all, one exists!) is weakest, then design and implement coherent STI policies that can address those deficiencies.

### *(2) Labour force skills and training*

Developing an educated and trained workforce (i.e. one that is able to engage in more knowledge-intensive production) entails a balance between formal education on the one hand and vocational or technical training on the other. Various countries have manipulated this balance to effect the transition from "low-wage, unskilled manpower" to a "higher-wage, skilled labour force." However, an enhanced supply of skilled workers must be matched by an increased demand for them on the part of enterprises targeting the country for skill-intensive activities. This is necessary in order to prevent a scenario in which investments in education and training result in a brain drain.

### *(3) Enterprise innovation*

Enterprises must have the capacity to utilize new as well as existing knowledge to innovate, design, produce, and market more knowledge-intensive and value-added goods and services. Otherwise, building STI capacity to acquire and produce knowledge will be of little relevance. In several countries, world- class R&D facilities co-exist alongside impoverished rural villages and uncompetitive local industries. All too often, public policy focuses on increasing the supply, quality and relevance of R&D as well as the supply of skilled workers on the assumption that demand for them already exists.

### *(4) Education: academic, vocational, training and R&D institutions*

Educational institutions are the main transmission media between the global stock of knowledge on the one hand, and enterprises and the workforce, on the other.

With regard to a skilled workforce, matching demand to supply requires educational and training institutions to have the flexibility, autonomy, desire, and technical capacity to respond to market signals and to work in partnership with potential employers in the private sector. All too often, these administrative and managerial pre-requisites are missing. If so, organizational and structural changes are needed.

R&D institutions, when operating optimally, serve a dual function of (1) producing new knowledge, and (2) helping to train the next generation of scientists. Alas, R&D institutes for the most part have weak links to the innovative needs of enterprises and hence fail to play an active role in training young scientists.

## Implications for STI Capacity-Building Policies

At any given stage of an STI capacity-building programme, policy makers need to decide exactly which aspects of capacity should be highlighted. Maintaining an appropriate balance between the different *types* and *dimensions* of STI capacity building is also vital. For example, should policy makers give priority to:

- *Creating new* knowledge or *acquiring existing* knowledge, and in which sectors of the economy?
- Increasing the *supply of* knowledge (e.g. bolstering education or R&D) or increasing the *demand for* knowledge in enterprises (e.g. promoting innovation or entrepreneurship)?
- Financing *physical hardware* (e.g. building new laboratories or acquiring new scientific equipment) or *software* (e.g. policies and programmes that heighten the incentive to innovate)?
- Formulating *horizontal policies* that establish a good business climate (e.g. reducing administrative barriers to starting a business or enhancing the protection of intellectual property) or *vertical policies* that strengthen the STI capacity in those sectors which the market has identified as probable winners?
- Developing *new* organizations, institutions and agencies or enhancing the capabilities, performance and linkages of *existing* ones?

In considering their options, policy makers will need to consider the strengths and weaknesses of a country's current STI capacities as well as the short-term and long-term *costs and benefits* of emphasizing different aspects of capacity building. There are obvious trade-offs here, and these can be assessed only in the context of the country's individual goals and objectives. In some instances, the trade-off will be a difficult one. For example, *both* financial and human resources will be scarce in the early stages of a country's development, so policy makers will not be able to target everything at once. Priorities will then have to be established and decisions made on which specific aspect of STI capacity building will generate the greatest "bang for the buck".

For most countries, the trick will be to find the appropriate balance between building different aspects of STI capacity. Building the wrong type of capacity may be just as detrimental as focusing too little on the right type. Similarly, improving STI 'hardware' is likely to bring results *only if* this is done in tandem with the appropriate 'software'. Furthermore, horizontal policies will probably need to be paired with appropriate vertical ones.

## Latecomer Strategies for Catching Up

The pre-forum paper was also aimed at stimulating discussion on the strategies that 'latecomer' countries might consider employing in order to catch up with their developed (or developing) counterparts.
There are many lessons that can be learnt from the experience of other developing countries which have been successful in catching up, whether in low-tech or high-tech sectors. Some of

these countries have exploited public-private partnerships to support the catch-up process and to foster local innovation.

Empirical evidence suggests that foreign direct investment (FDI) may not necessarily encourage local innovation and technological adeptness. Some countries attracting FDI have found that it does not necessarily lead to significant technological modernization apart from the benefit of direct employment for locals. Further, foreign firms are quick to notice lower-wage locations becoming available elsewhere – the flow of new FDI is diverted, growth slows dramatically and a country can find itself facing an economic crisis.

However, there are other countries which have proven quite adept at using FDI as a learning or technology-upgrading opportunity. Such countries may start with an abundance of low-wage, unskilled labour. But they quickly embark upon a deliberate process of upgrading skills and technology. Consequently, the foreign investors who were initially attracted by the low-wage labour are gradually induced to physically locate more knowledge-based and skill-intensive activities in the host country. These countries also position their local firms to provide value-added goods and services to the foreign investors and thereby build supply-chain linkages between local and global firms.

In terms of the role of R&D in the technology-upgrading process, both anecdotal (qualitative) and survey (quantitative) evidence imply that enterprises innovate primarily by importing modern capital equipment. There seems to be little demand for local R&D capacity on the part of most enterprises in middle-income countries as these tend to operate far below the technological frontier i.e. they do not find the need to finance or conduct R&D. Therefore, grant programmes to enhance R&D in the local private sector may be less effective than their proponents would wish.

### Technology Diffusion, Linkage, Leverage and Learning

Catching up means finding a niche in the global division of labour and using that initial niche to move from lower, value-added, less knowledge-intensive activities to higher, value-added, more knowledge-intensive activities. Getting an initial foothold and devising a strategy for moving up can prove difficult and complex.

According to Mathews[42], the most critical aspect of the catching-up process is the absorption, adoption and adaptation of products, processes and technologies that are already in use elsewhere. This is the process of *technology diffusion* which, as Mathews observes[43], requires an active, conscious policy of *linkage*, *leverage* and *learning*. Mathews also states, “the strategic goal of the latecomer is clear: it is to catch up with the advanced firms, and to move as quickly as possible from imitation to innovation.”

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[42] Mathews, John A. (2002) “Competitive Advantages of the Latecomer Firm: A Resource-based Account of Industrial Catch-up Strategies”, *Asia Pacific Journal of Management*. Vol. 19, No. 4, pp. 467-488.

[43] Mathews, John A. (2007) “Latecomer Strategies for Catching Up: Linkage, Leverage, and Learning”, *World Bank Development Outreach*. Vol. 9, No. 1, pp. 24-27.

Latecomer firms and latecomer countries must recognize and exploit a distinct advantage – the ability to tap into advanced technologies rather than devoting time, resources and effort to develop new technologies or industries from scratch.

Mathews identifies three essential tools for the catch-up effort:

- *Linkage:* Latecomer firms must link themselves to dynamic firms that already have a successful foothold in the global economy. The latecomer firm now has a window to the global marketplace and to technology trends.

- *Leverage:* Latecomer firms must devise strategies and develop the capacity to exploit the knowledge and opportunities generated by the above linkages to more successful firms.

- *Learning:* Latecomer firms must develop the capacity to absorb and adapt the knowledge generated via linkage and leverage and convert it into new, more profitable economic opportunities.

Mathews also emphasizes the role of public agencies and various forms of inter-organizational superstructures in creating the conditions under which the processes of leverage and learning can be applied over and over again but each time at higher levels of technological and organizational capability.

## Enterprise Capability

Latecomer firms require at least two distinct types of skills:

### *(1) Practical technology absorption, adoption and adaptation skills*

R&D is only the tip of the technology development and innovation process, as shown in Figure 7.1. Other non-R&D activities would include skills for: (1) acquiring, using and operating technologies at rising levels of complexity, productivity and quality, and (2) designing and engineering to generate a continuous stream of improvements and innovations.

Different skills are only suitable for different stages of technological development – R&D would be for firms closing in or are already at the technological frontier; technology-acquisition and utilization skills would be for firms that are at the assimilation or deepening stages.

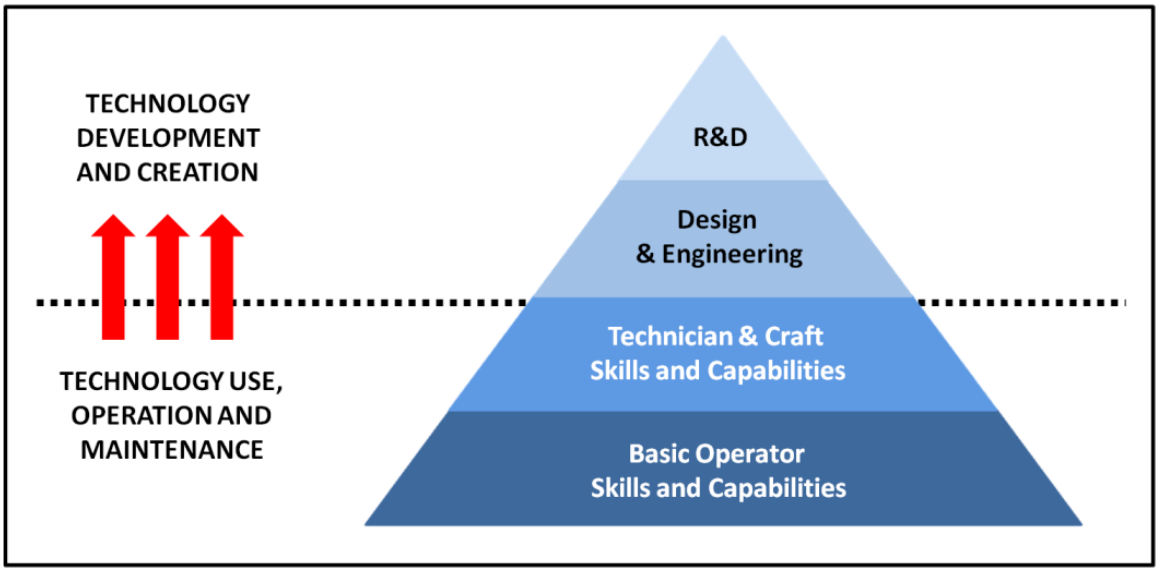


Figure 7.1: Hierarchy of the Structure of Industrial Technology

Source: "Building Science, Technology and Innovation Capacity for Sustainable Growth and Poverty Reduction" by World Bank.

As the pyramid above suggests, a much broader focus is needed than just promoting R&D. Technology creation (including design and engineering), acquisition and utilization skills need to be emphasized. These are all vital dimensions of technology development.

For enterprises in developing countries (which do not require cutting-edge R&D to improve their competitive standing), assistance in honing skills related to technology acquisition and use may be much more relevant than additional public R&D funding.

***(2) Strategic technology-acquisition skills***

Firms acquiring knowledge need to have the capacity to search for and evaluate different technological options, to modify off-the-shelf technologies for use, and to integrate new technologies into their production processes. Needless to say, these require a great deal of organizational, managerial, and technological sophistication.

Most importantly, the paper states that the forum will discuss how the *strategies* of countries successfully benefiting from technology upgrades can be appropriately adapted to other country contexts. This is intelligent imitation beyond mere policies and programmes.

## Strategic Operational, Organizational and Implementation Issues

It is not clear whether all policy makers are speaking the same language when they refer to "STI capacity building". Eliminating this conceptual or terminological confusion is important, not only for the sake of clarity, but because different aspects of capacity building serve different purposes and objectives, and hence entail developing different skills and institutions. A productive dialogue on capacity building will be difficult unless individual countries know what they hope to achieve and what type of STI capacity they wish to build.

## Decisions and Priorities

Sequencing and prioritizing would be necessary. A list of choices a country must make follows. Countries must decide either for one or the other, or strive to achieve some balance between the two stated aspects.

- (1) Build research capacity to absorb, adapt and adopt existing knowledge, or (2) create new knowledge.
- Develop the skills needed to (1) conduct world-class R&D, or (2) build knowledge-absorption capacity.
- (1) Boost supply of skills through education and training, or (2) boost private-sector demand for skills via technology- upgrading and innovation policies.
- Emphasize (1) frontier research in high-tech fields such as biotechnology and nanotechnology, or (2) improve the competitiveness and productivity of more 'mundane' industries such as food processing, machine building and horticulture.
- (1) Co-ordinate regional initiatives with other neighbouring countries, or (2) establish individual STI institutions locally.
- (1) Establish new, world-class STI institutions, or (2) convert selected, existing institutions into world-class centres of excellence.
- Drive research priorities with (1) purely scientific agendas, or (2) the country's social and economic development priorities.
- Organize STI capacity-building projects around (1) specific sectors such as health and agriculture, or (2) integrated, cross-sectoral efforts such as improving wellbeing in rural villages where a majority of the population is engaged in subsistence agriculture.

## A Synthesized Report

The 2002 World Summit on Sustainable Development (WSSD) resulted in a clarion call to all the nations of the world to hasten the formulation of national strategies that would collectively guarantee the preservation of the planet's diminishing resources. The summit also urged all governments to begin to implement effective conservation policies by 2005. It reminded participating countries that a national SD (sustainable development) strategy had to be more than a mere document published to demonstrate compliance with international norms. Rather, sustainable development is the outcome of national and worldwide adaptive processes of strategic and coordinated action.

Before and after the 2002 WSSD, the Canadian-based International Institute for Sustainable Development (IISD) and Stratos Inc., in collaboration with Germany's Deutsche Gesellschaftfür Technische Zusammenarbeit (GTZ) GmbH, conducted a collaborative research project involving 18 countries and the European Union as a whole. Through these 19 case studies[44], they sought to glean commonalities arising from the strategic and coordinated action toward SD taken at the national level. In 2004, the three organizations released a report that was *synthesized* from the findings of this joint endeavour. The report is titled “National Strategies for Sustainable Development: Challenges, Approaches and Innovations in Strategic and Co-ordinated Action” and is reproduced in full in Appendix 8.2. The individual case studies are available from ASM.

The IISD-Stratos-GTZ document is a scholarly treatise worth studying. Among other things, it espouses the emerging view that the traditional approach to the formulation of national plans is transitioning into something more dynamic. Exit the increasingly archaic *fixed* plan designed to cover a pre-designated time frame and enter its *adaptive* cousin that has the capacity to improve with each changing national scenario.

Lying at the core of the adaptive plan concept, as depicted in Figure 7.2, are four main management activities. These are (1) leadership, (2) planning, (3) implementation, and (4) monitoring, learning and adaptation. These four activities are all supported by the cross-cutting management aspects of co-ordination and participation.

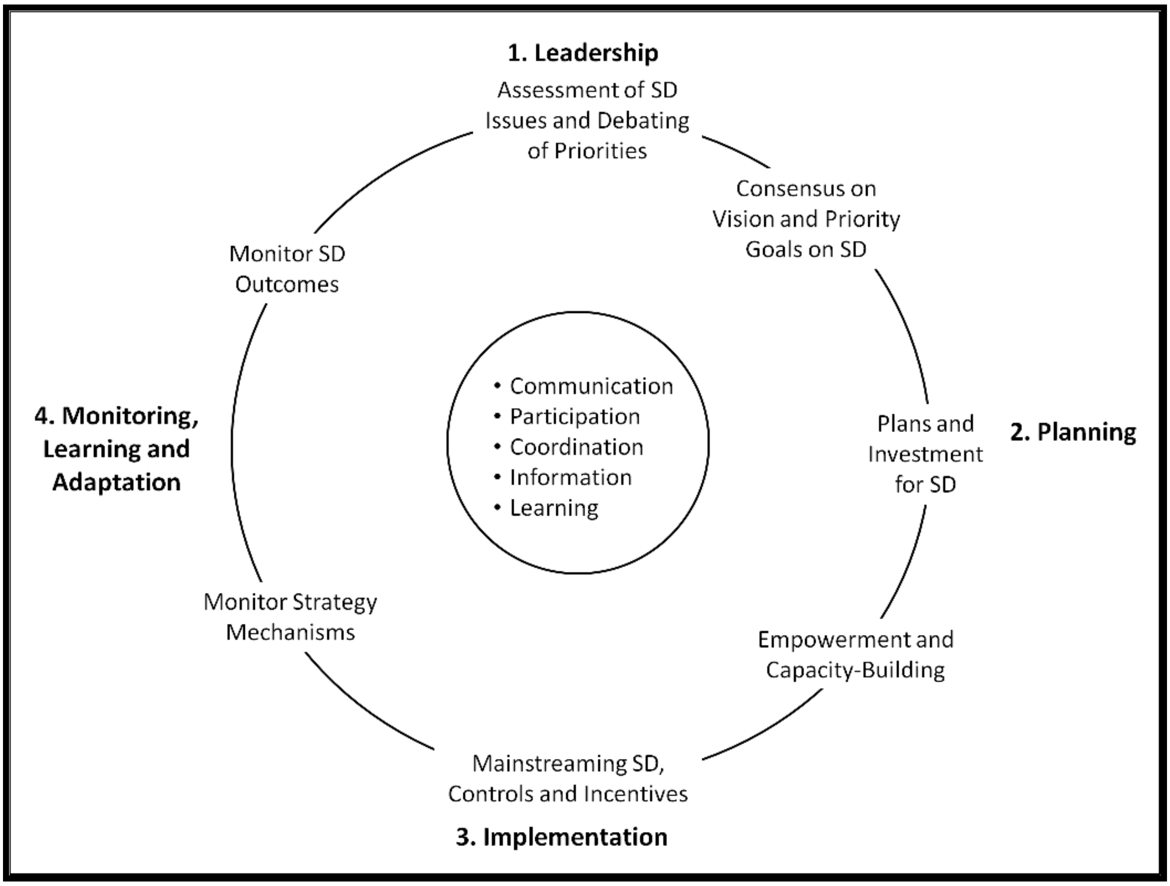


Figure 7.2: The Continuous Improvement Approach to Managing SD Strategies

Source: “National Strategies for Sustainable Development: Challenges, Approaches and Innovations in Strategic and Co-ordinated Action” by IISD, Stratos Inc. and GTZ.

[44] The 19 case studies covered Brazil, Cameroon, Canada, China, Costa Rica, Denmark, Germany, India, the Republic of Korea, Madagascar, Mexico, Morocco, the Philippines, Poland, South Africa, Sweden, Switzerland, the United Kingdom and the European Union.

The report first documents what has been discovered about the strengths and weaknesses of current strategic and co-ordinated SD-related action in each of the nineteen instances. It then examines what has been learned in each of the four components of the strategic management model i.e. leadership, planning, implementation, and monitoring/learning/adaptation. While doing this, it attempts to identify if the two named cross-cutting aspects of management – coordination and participation – have been observed.

The study team is hopeful that this brief introduction to the masterful endeavour by IISD, Stratos and GTZ will motivate the intelligent reader to peruse the entire document.

In the pages that follow, the reader is taken on a 'journey' through a number of countries with a view to learning whatever is on display with regard to SD planning activities.

# CANADA

In the broadest of terms, Canada's approach to sustainable development planning is two-tiered. Each ministry or agency of the government is given the mandate to prepare its own plan. *Another* agency then audits that plan by monitoring the progress made during implementation. The immediately obvious advantage of this system is the elimination of any favourable prejudice that might arise out of a self-audit arrangement. *This is a superb governance principle worthy of emulation everywhere.*

The North American giant is an exemplary nation in the area of conservation and sustainable development. The vast expanse of land within its borders is teeming with innumerable showcases of good SD foresight put into action. In looking for examples of international 'best practices', the study team zeroed in on what seemed, at first sight, an unlikely candidate. A Canadian government agency charged with the responsibility of moving people and goods from one locality to another seems hardly the kind of organization one would choose to exemplify the application of SD principles. Yet, the manner in which this agency goes about its day-to-day business warrants a careful scrutiny.

## The Canada Border Services Agency (CBSA)

The CBSA uses a performance-based management framework to plan and track all its activities. A cursory glance at its vision, strategic direction and policy statement will reveal that the SD concept has been written into the agency's framework documents[45].

At this point, the reader might ask why a *border services agency* should even bother itself with SD issues. Aren't such matters beyond the orbit of such a body? What has the management of a country's borders got to do with sustainable development? A careful study of the framework documents will provide some far-reaching answers.

[45] The specific document this particular sub-treatise was taken from is titled "Sustainable Development Strategy 2007-2009", available at: http://www.cbsa-asfc.gc.ca/agency-agence/reports-rapports/sds-sdd/sds-sdd-07-09-eng.pdf

The CBSA understands its mandate to be the provision of integrated border services to ensure the security and prosperity of Canada by managing the lawful flow of people and goods across the country's vast borders. It has resolved to strengthen this mandate by ensuring that its activities contribute to environmental quality, continued economic prosperity and social equity. The agency fully comprehends that in order to do this well, all its employees must:

- increase their awareness of the challenges associated with SD;
- understand the skills needed to meet these challenges; and
- integrate social, economic and environmental dimensions of SD into all of their decision-making processes.

We can thus safely assume that *all* the programmes, operations and activities carried out by the CBSA will fully conform to the SD requirements that have been incorporated into their decisions. This is a highly laudable starting position.

The performance-based management framework involves a portfolio of requirements that must be satisfied in order to realise the vision of the CBSA. These requirements become influencing factors in moving the organization towards achieving its stated objectives. Some of these factors are listed below:

- Leadership from the government and senior management must be clearly demonstrated.
- A sufficient level of financial and human resources must be committed to the stated cause.
- There must be a clear sense of shared SD responsibility and accountability across the board.
- All CBSA employees must give their full support to the SD concept.
- Each employee must be prepared for continuous learning and improvement through self-assessment.
- Simple and effective SD tools and processes must be developed and put into use.
- There must be effective communication and cooperation throughout the organization.
- Ideally, all the above should result in a number of specific outcomes that should materialize over the next four decades.

**Immediate Outcomes (10-year time-frame)**

- The awareness levels of employees are raised with the goal of increasing SD knowledge, skills and applications.
- Leadership and commitment to SD are demonstrated.
- The practice of balanced decision-making in policies, programmes and operations is increased.

- The integration of SD principles into decision-making processes has visibly begun.
- Federal environmental legislation requirements and 'best management' practices are met or exceeded.
- SD 'best management' practices in programme delivery and operation are implemented.
- New partnerships to support shared SD objectives are developed and enhanced.
- SD commitments to employees, partners, the public and visitors to Canada are clearly communicated.

**Intermediate Outcomes (20-year time-frame)**

- Employees are able to contribute meaningfully to SD.
- Effective systems are in place for SD.
- SD principles are integrated into all decision-making processes.
- Programmes demonstrate sustainable business delivery.
- All operations are managed sustainably and diligently.
- The CBSA is an employer of choice and a good corporate citizen with an enhanced corporate image.

**Ultimate Outcomes (40-year time-frame)**

- SD is part of the corporate culture and employees are empowered to think and act in a sustainable manner.
- Sustainable, efficient and innovative policies, programmes, and operations are in place.
- Modern comptrollership and triple-bottom line reporting on social, economic and environmental performance allows for transparent management of results.
- Conservation of natural resources is achieved through sustainable practices.
- Knowledge, innovation and technology are shared with international partners.
- Quality of life, equity and respect for diversity are integrated into all decision-making processes.

Clearly, there is so much that is worth emulating.

# CHINA

The world's most populous nation has been using a novel approach in its efforts to develop a large and strong STI capacity base. The Chinese government has been encouraging all STI capacity-building parties at tertiary level and beyond to *share their knowledge* and cooperate in their work. Critics might quickly see a communistic element in this practice. But the concept is a laudable one in that the progress-related needs of the nation are prioritized over the need of each individual to be recognized. Without a doubt, the practice of sharing raw data, information and initial results in R&D activities enhances correlation and reduces the redundancies inherent in isolated efforts.

## The Scientific Data-Sharing Programme[46]

The *Scientific Data-Sharing Programme (SDSP)* was launched in 2002 by the Chinese Ministry of Science and Technology (MoST). A schematic representing this programme is shown in Figure 7.3. Three years down the line, one-third of the existing public-interest and basic scientific databases in China had been integrated and upgraded. By June 2007, twenty-four government agencies had become involved in the programme.

After five years of hard work, great progress had been achieved in the policy and legal framework, data standards, pilot projects and international cooperation. By 2020, MoST is expected to have established a massive user-friendly *scientific data management and sharing system*, with 80 percent of all the country's scientific data available to the general public. In order to realize this objective, the managers of the programme are seeking to perfect the policy and legislation system, improve the quality of data resources, enhance the number of national scientific data centres and strengthen international cooperation. It is believed that the nationwide access to scientific data guaranteed by this programme will propel China into the forefront of STI R&D and capacity building.

China expects to achieve several key objectives by 2020. These are:

- To establish the necessary infrastructure for data sharing with a broad coverage of most basic science and public-welfare domains;
- To establish data policies, regulations and standards, and implement an operational sharing mechanism;
- To develop a technology-oriented service team with appropriate professional representation and the ability to adapt to social needs in the application of information.

The Chinese government spells out in no uncertain terms the fields which the SDSP is intended to cover. These are: (1) natural resources and environment, (2) agriculture, (3)

[46] Guan-Hua Xu. (2007) "Open Access to Scientific Data: Promoting Science and Innovation", *Data Science Journal.* Vol. 6, Open Data Issue. Also available: http://www.jstage.jst.go.jp/article/dsj/6/0/OD21/_pdf

population and health, (4) basic and frontier sciences, (5) engineering and technology, and (6) regional scientific and technical research. Further, the SDSP is meant to integrate and leverage all possible data resources – from the government to the private sector – and to make them available to the general public.

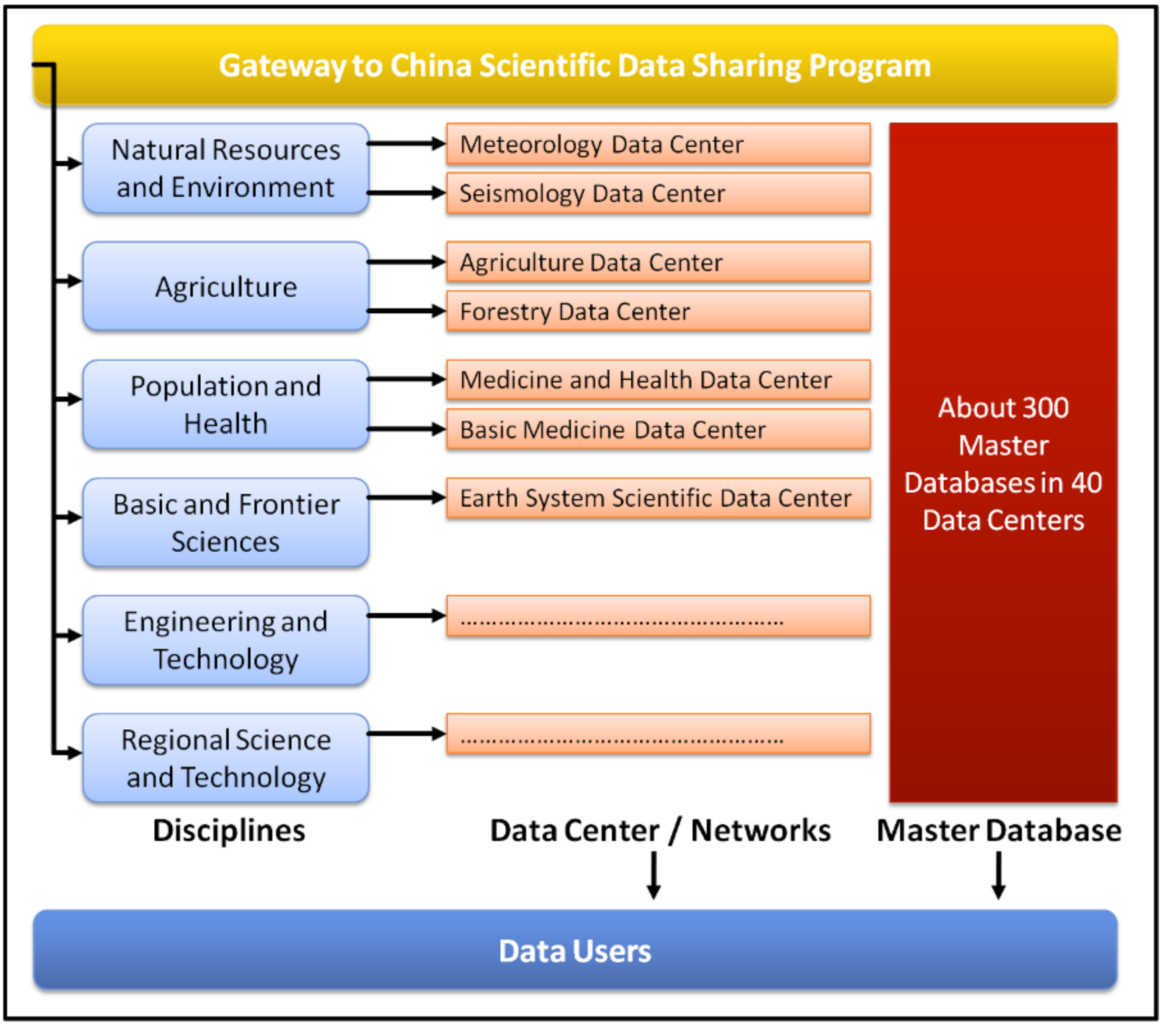


Figure 7.3: Structure of the Scientific Data-Sharing Program

Source: "Open Access to Scientific Data: Promoting Science and Innovation" by Guan-Hua Xu.

# Finland

The study team believes that dialogue with Finland on their approach to sustainable development can be beneficial to Malaysia. There are four specific areas that the Finns particularly excel in.

- An electricity production-and-supply system that guarantees *inexpensive* electricity for the country as well as competitiveness for its energy-intensive industries;
- Advanced technologies in electricity supply;
- Advanced technologies in CHP[47]; and
- Extensive experience in drawing up voluntary agreements that use a participatory mechanism to convince energy suppliers and energy users to abide by principles and rules that guarantee sustainable development.

Finland has also established effective procedures to develop technology roadmaps. Insight gained from the Finns in this area can prove invaluable to the Malaysian Government as it maps out the future of the country's energy technologies.

## SITRA

SITRA is a public foundation that reports directly to the Finnish Parliament. The independent body, chaired by the former Prime Minister, is tasked with the responsibility of promoting the economic growth and future success of Finland through international cooperation and competitiveness. The foundation's operations can be divided into two parts, namely, (1) research, education & collaboration, and (2) venture-capital funding. In the latter of these two operations, SITRA was clearly one of the country's pioneers.

The methods employed by SITRA include research, strategy-building processes, innovative experiments, business development and investment in internationalization. While the foundation's initial emphasis was research, it focuses today on its new venture-capital investments. The aim of any investment in the early stages is to create and develop a competitive and profitable business. The overall objectives are to make Finland a global leader in the high-technology marketplace and to improve the national innovation system with SITRA as a 'driving actor'.

Thus, the Finnish knack for applying technology and innovation-oriented funding to the processes of national development provides a good example for Malaysia to emulate, at least in some measure.

[47] Combined heat and power, also known as cogeneration, is the use of heat engines or power stations to simultaneously generate both electricity and useful heat energy.

# Iceland

Historically, the term *sustainable development* became fashionable after the publication of the Brundtland Report (1987) under the auspices of the World Commission on Environment and Development. In that report, sustainable development is defined as *development that meets the needs of the present without compromising the ability of future generations to meet their own needs*.

The Icelandic document titled "Sustainable Utilization of Geothermal Resources for 100-300 Years[48] " might seem irrelevant to the Malaysian context for the obvious reason that we have no geothermal resources. On the contrary, its principal elements can prove to be of great value in imparting a deeper understanding of the SD concept to Malaysian planners. First, it gives a real-life perspective on what the term sustainability can mean. Second, it provides guidance on how to *distinguish* between the terms "renewable" and "sustainable". "Renewable" reflects the *nature* of the resource while "sustainable" deals with *how* a resource is utilized.

# Ireland

In broadening and deepening its STI capacity, Ireland took the assumption that manufacturing growth is expected to remain a key driver of economic development[49]. In this manner, it links its capacity-building activities directly to economic goals. Since Malaysia is similar to Ireland in this (manufacturing) respect, a dialogue with Ireland on how the latter intends to build its STI capabilities whilst maintaining its manufacturing base would certainly be useful.

Some of the ideas developed by the Irish in the document cited are:

- Specific actions will be needed to move R&D results from research centres to commercialization;
- Additional steps will also be necessary to address intellectual property (IP) or commercialization considerations in research institutes and universities;
- The government should support resource-intensive and cross-institution projects; and

[48] The document was authored and presented by Gudni Axelsson, Valgardur Stefánsson and Grímur Björnsson, from the proceedings of the 29th Workshop on Geothermal Reservoir Engineering, 26-28 January 2004, available at: http://pangea.stanford.edu/ERE/pdf/IGAstandard/SGW/2004/Axelsson.pdf
[49] See the document titled "Strategy for Science, Technology and Innovation, 2006-2013", available at: http://www.deti.ie/publications/science/2006/sciencestrategy.pdf

- A single-point responsibility[50] for coordination and development of STI capacity will be needed.

What Malaysia could consider imitating are the structures and approaches the Irish have used to support the implementation of strategies, as listed below.

- Use a portfolio approach in selecting R&D priorities;
- Develop a technology-assessment process in which the assessment principles include (a) potential for quality research and critical mass[51] in the industry area, (b) potential to create an international uniqueness for the country in certain research areas, and (c) relevance to the country's future industrial, economic and social development;
- Decide what infrastructure is needed at which universities to support particular research programmes;
- A central monitoring and coordinating agency will oversee the efforts to enhance STI capacity and R&D[52];
- Sectoral research needs will be prioritized (in this case, energy-related research); prioritized research requirements will directly link university research, sectoral research and enterprise research so that all research investment can translate into economic benefit; and
- There will be clear and transparent reviews, evaluations, targets and indicators used to communicate progress to the oversight bodies and to the public.

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[50] In Malaysia's case, this should be MOSTI.

[51] The term "critical mass" describes the existence of sufficient momentum in a social system such that the momentum becomes self-sustaining and creates further growth.

[52] In this respect, Malaysia already has such an agency as identified in the NGTP and the MOSTI Strategic Action Plan.

# Japan

The document titled "Energy Policies of IEA Countries, Japan 2008 Review[53] " provides a detailed model of a policy framework needed to create and implement an energy-related SD plan. The study team presents here a mere overview of the more pertinent areas. This overview is aimed at showing how far-reaching and forward-looking Japan is in tackling the dilemma between the needful use of energy and sustainable development.

## Government, Regulatory Institutions and Other Organizations

Here, Japan makes it a point to list all its energy-related arms of government, agencies and organizations. It also defines the roles and responsibilities of each of these bodies insofar as they relate to energy usage and SD, as shown in Figure 7.4.

| Body | Areas of Responsibility |
|---|---|
| The Agency for Natural Resources and Energy (ANRE) under the auspices of the Ministry of the Economy, Trade and Industry (METI) | • Policies on energy security and supply<br>• Policies in harmony with the environment<br>• Measures to enhance vitality of the private sector<br>• Economic relations with other countries |
| Nuclear and Industrial Safety Agency (NISA) | • Safety and security of nuclear and other energy<br>• Industrial safety |
| The New Energy and Industrial Technology Development Organisation (NEDO) | • R&D programmes on technologies (energy, environment and industrial)<br>• Diffusion of such technologies |
| The Energy Conservation Centre, Japan (ECCJ) | • Information and public enlightenment<br>• Promote efficient use of energy in the industrial and transport sectors<br>• Involvement in international programmes for energy conservation |
| The New Energy Foundation (NEF) | • Public awareness about new energy<br>• Development of new energy-related industries<br>• Japan's energy self-sufficiency<br>• Japanese living standards |

**Figure 7.4: Some of the Energy-related Bodies in Japan**

[53] Available at: http://www.iea.org/textbase/nppdf/free/2008/japan2008.pdf

## Key Energy Policies

Here, Japan first introduces the legislation which sets the general guiding direction for its future energy policy. The "Basic Act on Energy Policy (2002)" prioritizes securing stable supply, environmental suitability and use of market mechanisms as key tenets of overall energy policy. Japan then proceeds to list two relevant policies since the act (Basic Energy Plan, New National Energy Strategy) and what they aim to do. Then, the country's position on the subject of greenhouses gases under the Kyoto Protocol is briefly explained. Energy is also an area promoted under its Science and Technology Policy.

Japan conducts *ex-ante*[54] policy evaluations by laying out targets and objectives of each policy, and the achievements and the challenges or factors leading towards the meeting or non-meeting of such targets. All energy and environmental policies are now evaluated by METI according to eight specific criteria. METI submits the results of its analysis every year when it makes its budget request. It is the *ex-post*[55] analysis that evaluates the effectiveness and efficiency of individual programmes and measures, and also the extent of conformity of results to the targets. The latter results are disclosed to the public.

## Encouraging Energy Efficiency Improvement and Technology Co-operation

As an expert in energy efficiency (EE), Japan has set up programmes to accept trainees to learn from its experience in raising EE standards. It has also provided experts to Asian countries with the aim of strengthening their EE initiatives. Also, as part of its participation in the Asia-Pacific Partnership (APP) on Clean Development and Climate, Japan has established task forces for eight of its major industry sectors[56] to reduce carbon dioxide emissions through the use of improved technology.

## Energy Taxes and Subsidies

Tax revenues from petroleum, gasoline and coal are in part used to finance measures related to energy conservation and new energy sources. Taxes are also imposed on most forms of energy usage.

Japan lists the array of subsidies provided by its government as of 1 January 2008. They cover a wide range of areas, namely, fossil fuels, non-fossil fuels, energy utilization and conservation, carbon dioxide emissions, power generation, uranium enrichment and nuclear power-generation technology.

[54] A forecast in advance

[55] Actual results

[56] These sectors are aluminium, buildings & appliances, cement, cleaner fossil energy, coal mining, power generation & transmission, renewable energy & distributed generation, and steel.

## Critique

The use of voluntary agreements, where possible, is beneficial because it allows the industry to meet specific objectives in a flexible manner. This voluntary approach can be complemented by including appropriate market signals that motivate reductions in emissions. It is essential to (1) conduct *ex-ante* cost-benefit evaluations of a proposed 'basket' of policies before selecting a policy to see if the *expected* gain is worth the *expected* cost, and (2) conduct *ex-post* cost-benefit evaluations to see if the selected policy achieves its objectives.

It is also extremely important to have a model that produces sound energy supply-demand scenarios so that the government has a vehicle to test alternative policy impacts. Energy-market participants can also use the scenario results to guide investment choices.

## Climate Change Policy

Japan has established a Global Warming Prevention Headquarters led by the Prime Minister with the Chief Cabinet Secretary, the Minister of the Environment and the Minister of METI serving as deputies. All other ministries are members so that all actions to mitigate climate change are closely co-ordinated[57].

Japan has, under the Kyoto Protocol Target Achievement Plan, established about 60 specific policies and measures to manage carbon dioxide emissions. The focus in the transport sector is on improving the fuel economy of vehicles. The focus in other fuel-using sectors, likewise, is to improve the efficiency of fuel use. Carbon uptake through forest sinks is also promoted.

The country has developed and is expanding a domestic-emission trading scheme. It is also exploring extending this scheme to small-and-medium sized enterprises (SMEs)[58]. Under this scheme, large businesses can buy *carbon credits* from SMEs that undertake activities to enhance EE and lower emissions. These credits are used by the large companies to meet their own targets under voluntary action plans. In exchange, they provide these SMEs with financial and technical support for EE and emission-reduction projects.

## Energy Efficiency: Policies and Measures

Japan clearly lists a number of policies and measures that support the development of energy efficiency (EE). They are matched below, in Figure 7.5, with selected examples or comments for illustration purposes.

[57] This set up appears similar to the recent Green Technology initiative in Malaysia. A review of the Japan approach might offer useful experience.

[58] Again, this would provide a good model for Malaysia in its local SME scene.

| Policy / Measure | Examples / Comments |
|---|---|
| Specific, measurable targets and time lines to achieve them | • Reduce dependence on oil in the total primary energy supply to 40% or less by 2030<br>• Improve energy consumption efficiency by an additional 30% by 2030 |
| Subsidy programmes for promotion of EE technologies | • Subsidy for $CO_2$ emissions reduction<br>• Subsidy for promoting the introduction of high-efficiency housing and building energy systems<br>• Subsidy for energy conservation technology |
| "Top Runner" programmes | Such programmes take, as the basis, the level of the most energy-efficient products at the time of the value-setting process. Values are reset periodically. |
| Unified conservation labelling programme | Manufacturers must indicate comparative efficiency of major electricity-consuming appliances.<br>Retailers are graded on the degree to which they promote energy-efficient products. |
| Regulatory measures [59] for the industrial sector | • Voluntary actions by the industry itself<br>• Subsidies, tax exemptions, loans for investment<br>• "Energy managers" report on progress made in high-energy-consumption facilities<br>• On-site investigations, penalties |
| Measures for the transport sector | • "Top Runner" programme<br>• Mandatory reporting by operators with large fleets of vehicles<br>• Eco-driving campaigns |

Figure 7.5: Policies and Measures That Support EE Development

## Nuclear Energy: Policy Framework and Regulations

Japan has established five basic guidelines to support the formulation of a nuclear energy policy. As a result, nine implementation policies in its Nuclear Energy National Plan were developed. These are:

1) Investment to construct new nuclear power plants and replace existing reactors in an era of electric-power liberalization.
2) Appropriate use of existing nuclear power plants with the assurance of safety as a key prerequisite.
3) Steady advancement of the nuclear fuel cycle and strategic reinforcement of nuclear fuel-cycle industries.
4) Early commercialization of the fast-breeder reactor cycle.

[59] Similar programmes are in place for Japan's residential, commercial and other sectors.

5) Achieving and developing depth in technologies, industries and personnel.

6) Support for the international development of Japan's nuclear power industry.

7) Active involvement in creating an international framework to uphold both non-proliferation and the expansion of the peaceful use of nuclear energy.

8) Fostering trust between the government and local communities on the matter of where plants will be located; highly detailed public hearings and public relations.

9) Steady promotion of measures for disposal of radioactive wastes.

10) A single ministry is charged with the sole responsibility of formulating safety regulations for nuclear power plants.

## Energy Research and Development: R&D Priorities

Japan specifically identifies the categories of energy-related technologies and programmes which it will firmly promote. Such technologies are those that will

- improve total EE;
- promote the peaceful and safe use of nuclear energy;
- contribute to the diversification of energy sources in the transport sector (e.g. electric and fuel-cell vehicles, storage performance of batteries, low-cost hydrogen systems);
- be related to new energy sources (e.g. the use of hydrogen and fuel cells, photovoltaic power generation, biomass energy);
- ensure stable supply along with the effective and clean use of fossil fuels; and
- be beneficial over the longer term.

## R&D Programmes and Projects

The Japanese government is also very clear on which types of technology will obtain funds for R&D programmes. These are (1) renewable-energy technology, (2) energy-conservation technology, (3) fossil-fuel technology, (4) nuclear technology (e.g. projects to improve the next generation of nuclear reactor); and (5) electric-power technology (e.g. projects related to power system improvements). The government also gradually reduces its support for all R&D programmes. The support level begins at 100% for early-stage leading research, steadily declining to 50% for demonstration research and finally to one-third for commercialization.

# Norway

The study of the document titled "Norway's Action Plan for Sustainable Development[60] " has produced a valuable illustration of what is required to successfully implement the SD planning process and the plan itself, in addition to monitoring the progress of SD in a country. It must be noted that Norway also includes this document in its annual National Budget by describing in the latter the steps required to follow up the former.

Presented below are the main points from the document that needs to be replicated. SD planning must ensure that any objectives, division of responsibility for implementation and follow up responsibilities are specifically and clearly stated.

## Some Broad Principles

- Sustainability must be viewed in the context of *stewardship*: in meeting its own needs, the present generation should not compromise the needs of future generations.
- The *principle of precautionary responsibility* should be exercised without compromise at all times. This means that if there is a lack of scientific uncertainty about any environmental effects resulting from a proposed development project, that uncertainty cannot be used as a basis to continue with that development. Malaysian authorities have been highly irresponsible on a number of instances in the light of this principle.
- Decisions on how to implement sustainable development must seriously consider maintaining the functioning of all ecosystems and ensure that human activity takes place within the tolerance limits of the natural environment.
- Polluters must pay. If any activity degrades the environment, the parties responsible must pay to either repair the damage or eliminate the elements causing such damage.
- There must be common responsibilities amongst countries for ensuring the ability of the world's resources to meet our needs, and an equitable distribution of the burden of doing so among nations. The onus must be on the richer first-world nations to shoulder a bigger portion of the burden. The same principle applies within countries in the form of different constituencies.
- Policies must incorporate the triple-bottom concept. This means that they must satisfy economic, social and environmental objectives simultaneously.

[60] Available at: http://www.rrcap.unep.org/nsds/pub/nat_action.pdf

## Stakeholders Involved

- The plan and the implementation processes must be a part of the government's everyday business. Without this, the plan will not succeed.
- Within the country, there can be no success unless everyone is committed and actively involved in doing business in a sustainable way. The non-exhaustive list of *everyone* includes citizens, companies, institutions and all arms and agencies of the government.

## Broad Processes and Mechanisms

- Establish a priority list of sustainability issues to be addressed. For Norway, these would be international cooperation, effects of climate change, biological diversity and natural resources. Malaysia needs to establish its own priority areas.
- In addressing each of these selected issues, set targets to be achieved and the time frames in which to achieve them.
- Develop quantitative indicators or tools to monitor progress in the achievement of targets.
- Any plan, in order to be successfully implemented, must be linked to the annual national budget.
- Each ministry must translate the overall national plan into its own specific plan and publish regular progress reports.
- Environmental Impact Assessments (EIAs), in addition to their normal application, are also useful instruments for implementing the aforementioned principle of precautionary responsibility.
- The aforementioned "polluter must pay" principle must be infused into the price mechanism for all products and services. This would limit the demand for such products and thus reduce the pressure on natural resources and the environment.
- International cooperation is essential to achieving certain SD outcomes.
- R&D is essential to (a) take advantage of energy-related opportunities that drive sustainable development, and (b) ensure that any negative effects from pursuing the opportunity are eliminated or greatly reduced. Again, international cooperation on R&D is needed to see good results in areas where expertise and resources are shared between countries.
- Norway identifies three main types of policy instruments: (1) economic instruments (e.g. incentives to influence behaviour), (2) administrative instruments (e.g. mandates or directives regarding behaviour) and (3) guidance and information instruments (e.g. providing information to make informed decisions).

The Norwegians incorporate a great deal of detail into their SD-planning processes. Consequently, their national plans translate into a range of definite actions that can be properly evaluated. It is note-worthy that the country has enjoyed successful implementation of their SD plans over the years. As an illustration of its commitment to SD principles, the Norwegian government has explicitly promised that it will:

- Continue funding an action plan for the development of biofuels through special agricultural agreements with partner countries.
- Consider introducing a programme for biofuels.
- Provide additional funding for the National Energy Fund and Enova[61] so that a shift towards more environmentally-friendly energy production can be achieved.
- Increase the contribution of renewable energy resources and waste heat for central heating to 4,000 GWh by 2010.
- Encourage the construction of wind generators with an annual production capacity of at least 3,000 GWh by 2010.
- Reduce the amount of mineral oils used for heating to 75% of the amount in 2000 by 2012.
- Initiate a mandatory green certificate[62] scheme for energy generation, preferably in a joint Norwegian-Swedish market.
- Utilize the existing hydropower infrastructure in an optimal manner and increase the number of mini hydropower plants. The government will do so by proposing to (1) increase the size (indicated by installed capacity) at which licensing becomes mandatory for power plants, and (2) raise the lower limit for tax purposes for power companies. These measures are expected to increase interest in building mini hydropower plants.
- Increase the domestic use of natural gas since this fossil fuel inflicts the least damage on the climate in terms of emission of polluting gases.
- Provide framework conditions that will make it possible to build gas-fired power plants with carbon dioxide reduction technology. Other more specific actions would be to (1) provide investment grants for such technology-equipped plants, (2) provide government grants for technology and product development, and (3) establish a state-owned innovation company, and (4) review state participation in the development and operation of infrastructure for natural gas.
- Aim for zero discharges to the sea from the petroleum sector.
- Prioritize environmental research, partly as a means of meeting challenges in areas where petroleum, fisheries and environmental interest coincide.

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[61] Enova SF is the Norwegian government enterprise responsible for promotion of environmentally friendly production and consumption of energy.

[62] Green certificates are tradable commodities proving that the electricity represented by the certificate was generated using a renewable energy (RE) source. One certificate would represent 1 MWh of RE-derived electricity.

- Work towards zero carbon emission in the transport sector by focusing on the use of hydrogen as a fuel.
- Review the possibilities of using hydrogen as an energy carrier[63] for purposes other than transport. In fact, in June 2003, the Norwegian Government appointed a committee which was mandated to formulate plans for a national programme to use hydrogen as an energy carrier.

All the above demonstrate what is needed for implementing a successful sustainable development planning process and plan. The reader will notice the 'omnipresence' of the government in all the initiatives and actions.

A follow-up plan is essential for success. Appendix 8.3, titled "Following up an Action Plan", provides a wealth of ideas in describing how the Norwegians have driven implementation. It is noteworthy that Norway has enjoyed successful implementation of its SD policies and plans.

# TAIWAN

The National Taiwan University has identified several *indicators* that can be used to measure progress in achieving sustainable energy-related development. These are:

- Carbon dioxide emissions per capita;
- Local air-pollution indices;
- Total investment in renewable energy resources;
- Ratio of imported non-renewable energy to the total consumption of non-renewable energy [64] ;
- Ratio of public investment in non-renewable energy to GDP;
- Consumption of primary energy per unit of GDP [65] ; and
- Consumption of renewable energy as a percentage of total primary energy.

Another document[66] provides useful information about the process Taiwan has used to increase the awareness of sustainability.

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[63] An energy carrier is any system or substance that contains energy for conversion as usable energy later or somewhere else. This could be converted for use in, for example, an appliance or vehicle.

[64] This ratio is called *energy vulnerability*.

[65] This ratio is called *energy intensity.*

Taiwan's implementation process has not been sufficient in moving its society towards sustainability. That change will require more social and political engineering work over an extended period of time.

A member of a local EIA committee observed that development projects in the country have often continued without regard to environmental concerns. In addition to that, the administrative and legislative branches do not seem to have the long-term development of the country and the interest of future generations at heart.

# THE UNITED KINGDOM

The document "Innovation Nation[67] " by the Department of Innovation, Universities & Skills of the UK describes the plan of action the department will take to expand and accelerate innovation activity. This plan is expected to lead to an expansion of innovation opportunities and the resultant products and services created by such activities.

A key element of this plan is to create a greater demand for innovation and this is to be accomplished by:

- Making each government department include an "innovation procurement plan" as part of its commercial strategy describing how it will drive innovation.
- Focusing the Small Business Research Initiative (SBRI) [68] on technology-based research and prototyping.
- Facilitating the interchange of innovation expertise between the public and private sectors.
- Identifying how existing regulations promote or hinder innovation, and creating new regulations that are needed to promote or facilitate innovation.

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[66] It is important to note that the National Green Technology Policy has already incorporated a number of the Taiwan approaches. It remains now to fully implement the policy.
[67] Available at: http://www.bis.gov.uk/assets/biscore/corporate/migratedD/ec_group/18-08-C_b

[68] SBRI is a programme aimed at using government procurement to drive innovation by providing business opportunities to innovative companies through short-term development contracts. Such procurement also solves the needs of UK government departments for new technologies.

# THE UNITED STATES OF AMERICA

In the document titled “Building a Sustainable Energy Future: U.S. Actions for an Effective Energy Economy Transformation[69] ”, the US government clearly demonstrates its intention to lead a nationally-coordinated research, development, demonstration, deployment, and education (RD3E) strategy to transform the national energy system into a sustainable-energy economy that is far less carbon intensive.

The sub-strategies to realise the over-arching strategy include:

- Adopting stable policies that facilitate discovery, development, deployment, and commercialization of sustainable energy technologies;
- Establishing a federal leadership body to coordinate all activities related to sustainable energy;
- Adopting sustainable energy measures and analyses throughout the Federal Government;
- Organizing energy-related research, development, demonstration, deployment, and education (RD3E) activities across the USA to link scientific discoveries with technological innovation;
- Increasing federal investment in sustainable energy R&D;
- Encouraging investment in research aimed at commercialization of sustainable-energy technologies;
- Bolstering science-and-technology education related to sustainable energy at all levels;
- Bolstering the workforce training in sustainable energy-related fields;
- Engaging in global cooperation for sustainable energy strategies;
- Reducing barriers to cross-national collaboration in sustainable energy-related research; and
- Informing consumers and motivating the public to actively seek out, invest in, and implement energy-saving practices and technologies.

Most or all of the above ideas are worth careful consideration.

[69] Prepared by the National Science Board of the USA, available at: http://www.nsf.gov/pubs/2009/nsb0955/nsb0955.pdf

Malaysia is currently addressing a number of ideas identified in another study titled "Building a Science, Technology, Engineering and Math Agenda[70] ". Useful ideas from this study include:

- Incorporating STEM (science, technology, engineering and mathematics) education at the primary and secondary levels so as to create a coherent STEM education process;

- Aligning STEM education standards and assessments towards post-secondary and workforce expectations;

- Identifying various ways, including an appropriate reward structure, to improve the quality of teaching; and

- Identifying new teaching approaches and models that focus on rigour and relevance to ensure that all students are STEM literate.

The ability to innovate and compete directly on a global level will depend very much on the adequacy of secondary education to breed students that can take advantage of STEM literacy. To succeed in the knowledge-based work environment, students need to be proficient in all four areas of STEM, namely:

- Scientific literacy – the ability to apply scientific knowledge in decision-making in the natural world.

- Technological literacy – the ability to understand, use, manage and assess various technologies.

- Engineering literacy – the ability to understand how technologies are developed.

- Mathematical literacy – the ability to analyze, interpret, reason and communicate solutions to mathematical problems in a variety of situations.

The mark of a "STEM classroom" is one that emphasizes critical thinking and application of STEM knowledge in everyday life. However, a student's STEM-competency can be achieved only if teachers are STEM-competent in their respective areas.

The two key messages here are:

- There can be no progress in STEM capacity in the country without a fully STEM-competent and highly-motivated teaching cadre.

- Effective STEM education at the primary and secondary levels would require a massive change in the education process from the current "examination-oriented" structure to a structure that emphasizes critical thinking and application of STEM knowledge.

Clearly, the STEM concept is at the heart of STI capacity building taking place at the most fundamental levels of the education system. Without the introduction of STI education

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[70] Prepared by the National Governors Association of the USA, available at: http://www.nga.org/Files/pdf/0702INNOVATIONStem.pdf

through STEM at the primary and secondary school levels, there is very little chance to achieve STI capacity development at the tertiary level.

# CHAPTER EIGHT

# Recommendations from the Study Team

## A HIGH-LEVEL FRAMEWORK

### The Need for a High-Level Framework

The reader might recall how it was clearly established in Chapter 1 that the overarching objective behind this massive study undertaken by ASM was the creation of a high-level framework to assist the government in its role of leading the nation in the pursuit of sustainable development.

In this chapter, we first discuss and develop a possible framework that the government might wish to adopt in order to streamline its actions in

- enhancing sustainable development planning in the country;
- expanding the national STI resource base to be able to take advantage of energy-related opportunities; and
- initiating actions to capture an initial set of high-payoff energy-related opportunities that are expected to be available in the short term.

The three directions of streamlined government actions highlighted above are all necessary to ensure that the country will have energy resources that are accessible, secure, acceptable and sustainable, and that there will continue to be robust technology-driven economic growth.

However, our sincere attempt to develop such a framework has been dogged by a number of caveats.

- The study team members were not privy to every single one of the current plans and policies dealing with challenges and opportunities in the energy sector.
- The study team members had no in-depth knowledge about the government's preferences with regard to development plans.
- A significant amount of relevant information became available only towards the end of 2009. This coincided with the winding-up of the study. The fact that a time lapse of one full year has ensued between the conclusion of the study and the publishing of the final report would seem to inject an air of obsoleteness into some of the team's findings and recommendations.

Despite these hindrances, the team members believe that the study gives credence to their position that ASM has the wherewithal to advise the government on the changes that must be made in the formulation of development plans.

During the course of the study, the team became aware of a number of parallel studies related to sustainable development and enhancement of the country's STI resource base that were being undertaken by other parties. A representative list of these endeavours, starting from the most recent, follows.

- Study to Formulate a New Energy Policy for Malaysia (2010-2030), being conducted by the Malaysian Government; in progress.
- The Brain Gain Malaysia Programme, Dr Fereidoon P. Sioshansi, Menlo Energy Economics (USA), December 2009.
- Report on the Proceedings of the Brainstorming Session on Renewable Energy, MNC/CIGRE Malaysia and PTM, 2009.
- Progress Report 1, National Energy Efficiency Master Plan Study, KeTTHA, October 2009.
- The National Renewable Energy Policy and Action Plan, KeTTHA, April 2009.
- MOSTI STI Strategic and Action Plan (2010-2020)
- The National Green Technology Policy, KeTTHA, 2009.
- The 3rd Outline Perspective Plan
- The National Higher Education Plan (2007-2010)
- The 9th Malaysian Plan (2005-2010), EPU
- The 3rd Industrial Master Plan (2005-2020)
- The 2nd Industrial Master Plan (1996-2005)
- The National Bio-Fuel Policy, 2009.
- The 2nd Outline Perspective Plan (1990-2000)

A careful review of each of the above-mentioned plans and policies revealed that there were virtually no cross-references between all these nonetheless laudable attempts. It appears that each plan or policy was constructed to deal only with those areas that were of concern to the formulating party. None of these studies was prepared within a framework that had an overarching objective and a single set of goals that the government wanted to achieve. Consequently, the current situation is one in which there are numerous plans and policies for development in a number of key areas but none of these is comprehensive. At times, related areas of vital significance are not sufficiently addressed. A considerable degree of overlapping is evident everywhere.

In order to streamline the efforts of all the parties concerned and maximize the gains that can be derived from the collective knowledge, wisdom and experience of those involved, the study team is strongly recommending that the government establish a formal framework within which all the planning for the country's energy future will have to take place. This will require a paradigm shift on the part of the top leadership and a strong political will to tread a path that has never before been trodden.

The establishing of such a framework will bring a set of clear advantages. Planning in each area will continue to be done by the organization best qualified to do so but the formulation of the plan or policy will have to stay within the bounds of stringent overarching objectives identified by the government. Furthermore, the planning will have to be structured so that a mere glance will reveal if the goals and objectives are being met. The government will also be able to identify which ministries are meeting the sustainable development goals they are responsible for and which are not. In this way, corrective action can be taken to improve the performance of the faltering ministry. During the preparation of the Annual Budget, the government will be able to review each ministry-specific budget proposal in the context of the proposed plans and policies, then distribute the allocation of funds in favour of those ministries that are expected to make the greatest contribution to achieving the stated goals and objectives. Additionally, at the end of each fiscal year, the progress of the policies and plans can be measured against their stated targets to determine if the organization delivered on its promise toward the achievement of the government's overarching objectives. The next Annual Budget can then be adjusted accordingly.

## Constructing the Framework

This framework should comprise three levels:

(1) A *supreme authority* that would be responsible for developing the government's overarching *objectives* with respect to enhancing sustainable development of the Malaysian economy in the energy sector through the expanded use of STI resources.

(2) A *managing authority* that would be responsible for:

- developing the government's specific *goals* with respect to the energy sector and STI resources for the following specific time periods: (1) 2010-2015, (2) 2015-2020, (3) 2020-2030, and (4) 2030 and beyond;
- preparing and disseminating, in a timely manner, the guidelines that define the overarching objectives and goals relative to enhancing sustainable development which each organization that is developing plans and policies must follow;
- reviewing the plans and policies that are developed to see if they focus on meeting the targets and achieving the objectives set by the supreme authority;
- monitoring the activities of the organizations that are developing their policies and plans to identify the causes for any major delays that may be occurring so that it can report to the supreme authority with recommendations regarding the actions needed to ensure that the commitments made by the organizations can be met by the end of the relevant time period; and

- offering “consulting assistance” to the organizations that are developing and implementing the sustainable development policies and plans. This consulting assistance is (1) derived from the knowledge and insight that the managing authority would gain from working with the supreme authority, and (2) intended to improve the quality of the policies and plans and ensure that the implementation of them is efficient and effective.

(3) The *organizations* that would be responsible for specific planning processes. These could be ministries, departments, Energy Commission, agencies, special units, etc.

Figure 8.1 schematically expresses all the above ideas.

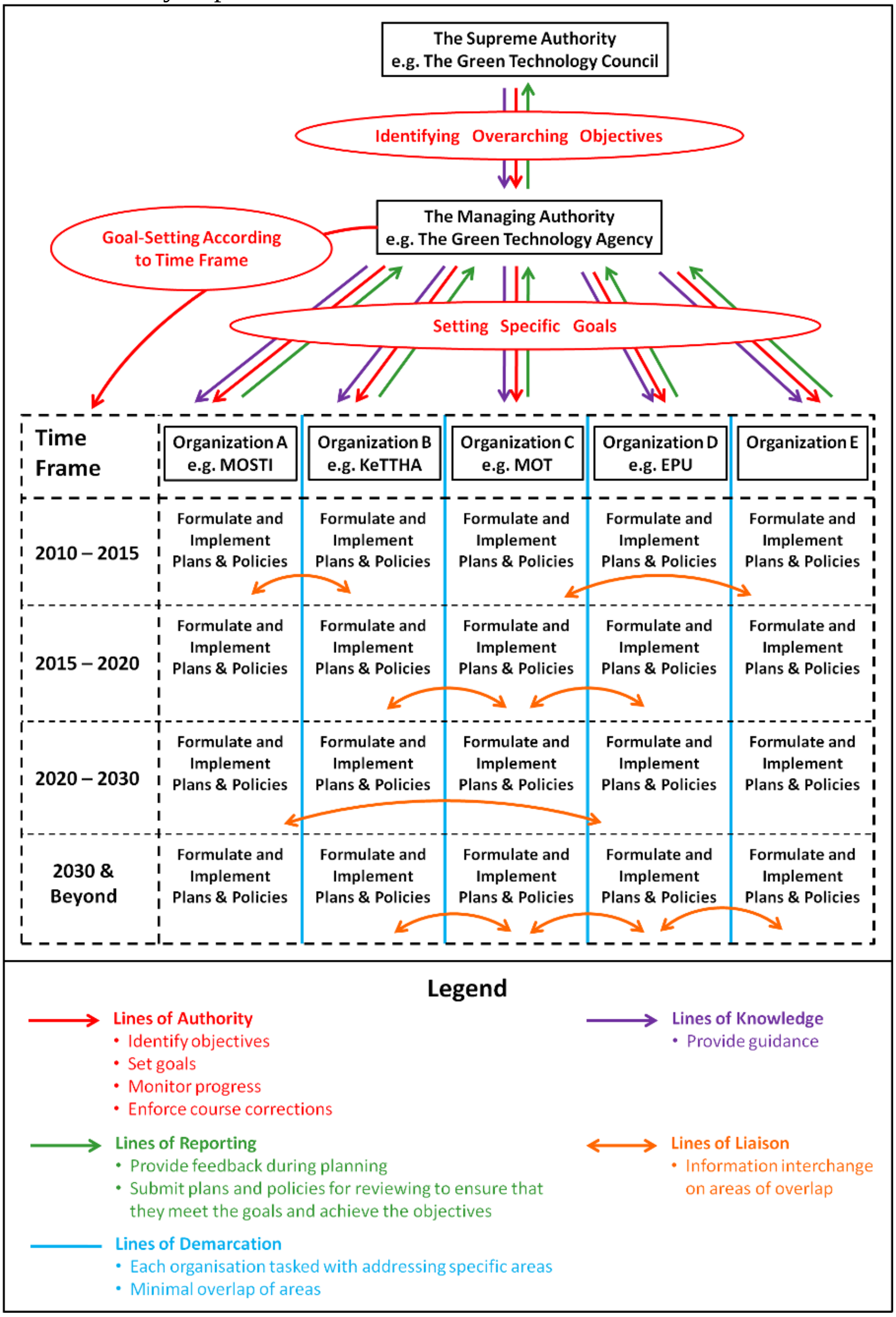


Figure 8.1: A High-Level Framework for Sustainable Development in the Energy Sector

Notes:

(4) The third level of the framework appears to target four existing organizations within the country. This is not the intent as these are mere examples. This level extends to as many organizations or parties that the government deems appropriate.

(5) The organizations identified at the end of each orange liaison arrow are, once again, mere examples. The degree of overlap that is expedient and the extent of liaison between any two or three organizations is to be determined by the managing authority.

(6) The basis for selecting members of the supreme authority should be totally devoid of a political agenda. The members of the authority should be competent persons in the business, economic, engineering and scientific communities.

The key to the success of this framework in identifying objectives and targets and ensuring that all policies and plans are guided by these is for all the parties concerned to have the necessary authority to carry out their duties. The study team believes that the National Green Technology Policy provides the governance structure, directional guidance and operating elements needed for such a framework to be successful. Hence, a possible candidate to play the role of the supreme authority in the proposed framework would be the Green Technology Council. The members of the managing authority could be the members of the Green Technology Agency. The organizations in the framework would then be the various line ministries, agencies, the Energy Commission and special units that are already in existence.

# THE NATIONAL GREEN TECHNOLOGY POLICY

The reader was introduced to the National Green Technology Policy (NGTP) in Chapter 4. There, the objectives and goals of the NGTP were clearly identified and the policy was represented as the much-needed ‘antidote’ for overcoming the many shortcomings and weaknesses in the country’s energy-related governance structures.

The NGTP is built around five fundamental strategic thrusts that provide consistency and continuity for future sustainable development planning efforts.

**Thrust 1: Strengthen the Institutional Frameworks.**

- Positive move has been made with the formation of a Green Technology Council chaired by the Prime Minister for high-level coordination among government ministries, agencies, the private sector and key stakeholders for effective implementation of the NGTP.
- Positive move has been made with the establishment of a Green Technology Agency for the effective coordination and implementation of green-technology initiatives and programmes.
- Review and establish the legal mechanisms necessary to foster the accelerated growth of green technologies in line with the NGTP’s objectives and goals (see Chapter 3).
- Enhancement of institutional clarity so that all agencies are aware of their respective roles and responsibilities.

**Thrust 2: Provide a Conducive Environment for the Development of Green Technology.**

- Introduction and implementation of innovative economic instruments supported by the necessary monetary and fiscal measures to foster accelerated growth of green technology in line with the NGTP’s objectives and goals (see Chapter 3).
- Strengthening the understanding of local players in green-technology industries and its value chain (including that of supporting industries) through various industry-enhancement programmes.
- Promotion of foreign direct investments (FDIs) on green technology which foster domestic direct investments (DDIs) and local industry participation and development.
- Establishment of strategic green technology hubs throughout the country, expanding from the core value chain to the upstream and downstream of the industry.
- Establishment of a green-technology funding mechanism.

**Thrust 3: Intensify Human-Capital Development in Green Technology.**

- Design and enhancement of training and education programmes to improve human-resource capacity related to green technology.
- Provision of financial and fiscal incentives for students to pursue green technology disciplines at undergraduate and postgraduate levels.
- Implementation of re-training programmes and apprenticeship schemes to enhance competence of semi-skilled labour to meet the demands of the green-technology industry.
- Formulation of grading and certification mechanisms for competent personnel in green technology.
- Exploitation of brain-gain programmes to strengthen local expertise in green technology.

**Thrust 4: Intensify Green-Technology Research and Innovation.**

- Provision of financial grants or assistance to the public and private sectors in RDIC.
- Implementation of green-technology foresight.
- Establishment of an effective coordinating agency for RDI and centre of excellence or new research institute for green-technology development.
- Enhancement of smart partnerships between the government, industries and research institutions.
- Establishment of strong linkages between local research institutions and regional and international centres of excellence in green technology RDI.

**Thrust 5: Promote Awareness Amongst the Public**

- Effective and continuous promotion, education and information dissemination through comprehensive roll-out programmes to increase public awareness of green technology.
- Effective involvement of the media, NGOs and individual stakeholders in promoting green technology.
- Inculcation of a culture that appreciates green technology amongst students at all levels through the development of effective syllabuses in the education system.
- Programmes to demonstrate effective green-technology applications.
- Adoption of green technology in all government facilities and government-linked entities.

In order to measure the progress of the policy toward achieving its objectives, actual results should be compared with indicators like those shown in Figure 8.2.

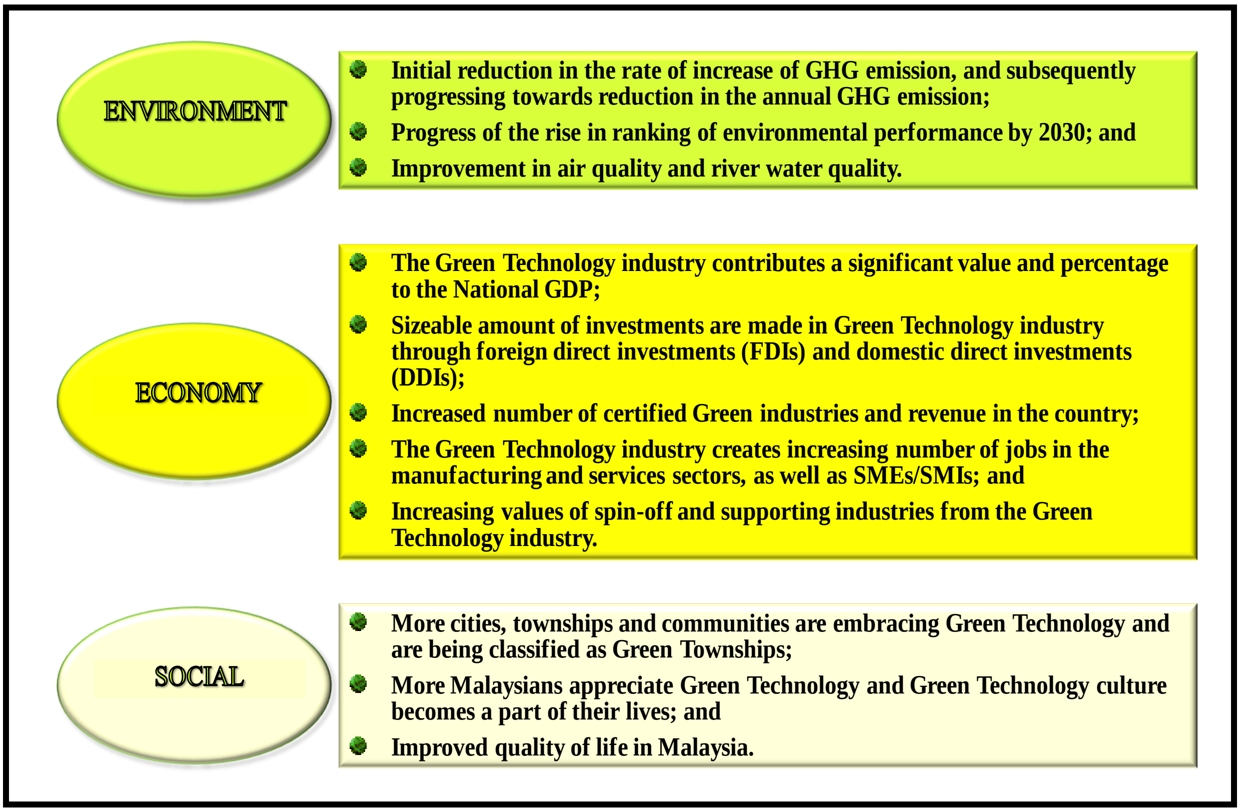


Figure 8.2: National Key Indicators

Source: Ministry of Energy, Green Technology and Water, 2010

It is important to understand the broad objectives that the Ministry of Energy, Green Technology and Water (KeTTHA) had in mind in formulating the NGTP as these will influence how it implements the new policy. KeTTHA's objectives are:

- To review and formulate policies on green technology to ensure sustainable development, enhance quality of life and ensure betterment of the environment.
- To formulate policies to enhance economic development of green technologies.
- To promote policies to support development of green-technology innovation for application to and management of potential risks.
- To formulate policies to develop and promote a culture of resource-use optimization.
- To institute a legislative and regulatory framework to support the development of green technologies in the country.

The specific actions that KeTTHA plans to take in implementing the policy are listed below:

- The creation of a *National Green Technology Advisory Council* to monitor the progress and implementation of green technology.
- The creation of an effective implementation agency for green technology with one of its functions being 'inventorizing' of new green technologies and horizon scanning.

- Promote the creation of new opportunities for developing green businesses, including the manufacturing of “green products”.
- Re-orientation of existing industries to adopt green practices.
- Development of R&D strategies in green technologies towards commercialization for the local environment.
- Enhancement of human-capacity development for green technologies.
- Establishment of strategic alliances with relevant key stakeholders, both local and international.
- The creation of a Green Technology Fund (which will be elaborated on later in this chapter).

The policy identifies the advancement of green technology as being critical to the sustainable economic growth of Malaysia. The country is obviously in need of a new energy roadmap, and the key thrusts inherent in the policy will guide the development of this roadmap. The roadmap will be made operational through the newly-formed Green Technology Advisory Council, the Cabinet Committee on Green Technology and the newly created Malaysia Green Technology Agency.

It will be vital to ensure the continuity of the above institutional framework as the country passes through each election cycle. This is the only way to guarantee any measure of consistency in the advancement of a national green technology agenda. It is hoped that at some point in the near future, a concerted effort will be made to pass the necessary legislation that will give the three bodies in the framework a continual legal standing regardless of political masters. Hopefully included in this legislation will be an obligation to update this energy-related mega-science study every five years. In this way, the government will have up-to-date input regarding energy-related decisions for the decade following the completion of the update.

# INTERNATIONAL BEST PRACTICES

## STI Capacity Building and SD Planning

In Chapter 7, examples of successful SD-planning activities on the international scene were given. These will shortly pave the way for a discussion which summarizes some useful ideas which Malaysia might wish to adopt. However, before re-visiting our global neighbours, we first examine some general ideas that merit our attention because, in the opinion of the study team, they have been tested and proven to be true.

- Government policies that encourage entrepreneurship are most likely to result in increased innovation.
- There are two 'catalysts' of innovation: consumers (demand-pull) and manufacturers (supply-push), and both should be encouraged.
- There must be a strong educational system that produces a well-educated, competitive labour force which embodies both skills and ideas.
- There must be a strong and transparent capital market that operates by world standards.
- Excessive government bureaucracy that needlessly increases cost and slows decision-making must be reduced or eliminated.
- Robust R&D programmes must be championed, especially in energy-related areas.
- Failure of some ventures should be expected. For example, if a *genuine* business initiative does not succeed, the tax code should allow the expense to be written off. Such failures should be recognised as learning experiences.
- Public-private partnerships must be promoted. The government, universities, research institutes and businesses must work together.
- Tax codes must be 'innovation-friendly'.
- Large companies need conscious and aggressive policies to support innovation since being engaged in substantial R&D is not a part of their core business.
- Success in innovation must be recognized and rewarded.

It is also important to note that the principles of SD-planning espoused by the NGTP appear to be as good as those found in any other advanced country. For the NGTP to succeed, the study team strongly urges that consistent actions be taken over time in the direction of the policy and that the required resources be made available for such initiatives. The reader will see elements of the policy emerging everywhere in the discussion that follows.

The reader is now invited to consider what specific lessons the leaders of this country can learn from the wealth of international experience.

## A Synthesized Report

The first useful idea from the IISD-Stratos-GTZ document is to consciously adopt a *strategic management model* for guiding SD-planning processes in Malaysia. The reader will recall that the model is made up of four main management activities, namely, (1) leadership, (2) planning, (3) implementation, and (4) monitoring, learning and adaption. All four are shored up by the cross-cutting management aspects of coordination and participation. The benefits of using such a model are described in the original document.

The second useful idea is to apply the suggested model to the NGTP. This application will highlight the key elements in the policy that need to be addressed throughout implementation. These would include

- deciding the measures and monitoring processes necessary to track the progress of green-technology initiatives;
- establishing the mechanisms that will assess all initiatives within an integrated SD framework;
- defining the Green Technology Agency's authority to carry out its *coordination* and *implementation* responsibilities; and
- establishing the policies that will govern the consolidation and *coordination* of financing arrangements for all energy-related SD initiatives.

The completion of each management activity as per the model will determine the success of the Malaysian SD-planning processes as well as the NGTP. All said and done, it is noteworthy that the NGTP has already made a significant start in addressing a number of recommendations in the IISD-Stratos-GTZ report.

The NGTP creates a potentially strong leadership nexus and cadre with the establishment of the Green Technology Council and the Green Technology Agency. The latter is responsible for

- *coordinating* and *implementing* green technology initiatives;
- ensuring a proper legal framework to facilitate SD-planning; and
- clarifying the roles and responsibilities of all government msinistries and agencies with respect to SD planning.

Strategic thrusts 2 to 5 of the NGTP (presented earlier) demonstrate an understanding and appreciation of the challenges that will need to be overcome to implement a successful SD process.

## Iceland

To recap, the document quoted in Chapter 8 had already defined three specific terms – "sustainable development", "renewable" and "sustainable". One of the main reasons why initiatives directed at wider audiences fail is because words and concepts are not clearly and consistently defined and used from the very outset. The audience thus has a diverse understanding of what is to happen. The result – effort is wasted, interest is lost and actions are focused in the wrong direction. Thus, it is extremely important for the NGTP to clearly define its terms and concepts so that all the stakeholders can understand the desired end state and what needs to be done to reach that state.

## Japan

The document titled "Energy Policies of IEA Countries, Japan 2008 Review" provides a number of valuable ideas on what the Malaysian SD plan should look like in its end state.

Such useful ideas are as follows.

- Policies and plans must set specific numerical targets to be achieved by specific dates.
- Before a policy is adopted, it should be subjected to a cost-benefit review i.e. an *ex-ante* evaluation. By comparing the value of a policy to its cost of implementation, the most cost-effective way of achieving results can be identified.
- After the policy is adopted, there should be periodic *ex-post* evaluations to confirm that it is indeed delivering on the expected benefits. If, however, this is not the case, then (a) adjustments must be made, and (b) the weaknessses in the policy leading to below-expectation results must be identified. This is essential so that the same mistakes will not be repeated in the formulation of future policies.
- Malaysia should join the *Asia-Pacific Partnership (APP) on Clean Development and Climate* in order to gain access to the work Japan has done to reduce carbon dioxide emissions for eight of its major industry sectors.
- Malaysia should organize *genuine* "lawatan sambil belajar" programmes to Japan so that trainees can benefit from Japanese expertise in raising EE standards. Malaysia should also consider inviting Japanese experts to our shores to assist in implementing advanced emission-reduction projects.
- Policy makers should review the full range of energy-related subsidies used by the Japanese. From such reviews, useful ideas regarding government funding can be obtained e.g. the stages at which the Japanese government phases out its funding support for R&D projects.
- Cooperation between the government and various industries can be achieved through the use of voluntary agreements. The onus will then be on the industries to meet specific emission-reduction objectives using least-cost approaches i.e. the government should specify the objectives, leave the means of achieving them to the industries, but hold the latter fully accountable.

The Japanese eloquently demonstrate how important it is to have a sound model that simulates plausible energy supply-demand scenarios. Such a model continually provides the government with the means to test alternative policies. Energy-market participants can also use the results of simulated scenarios generated by the model to guide investment choices.

Since the functional structure of the *Global Warming Prevention Headquarters* established by Japan appears to be very similar to that of the NGTP, it may be useful for Malaysia to scrutinize the structure with a view to gleaning any ideas worth emulating.

The Japanese have established about 60 specific policies and measures to manage carbon dioxide emissions from various sectors. Their environmental experts additionally focus on particular areas within those sectors. We should thus review such policies in greater detail to garner more ideas that can be implemented in our efforts to reduce GHG emissions.

A Malaysian variant of Japan's "Top Runner Programme" should be adopted. How the Japanese programme operates has already been outlined in Chapter 7.

Given Japan's expertise in the development and use of nuclear energy, a study on how that country sets and implements policies governing *all aspects* of its nuclear energy development would certainly be useful. **However, in hindsight, it is now more important to gain an insight into the recent failures (post-tsunami in Sendai) in the nuclear power sector, including the potential "meltdown" scenario that was being portrayed.**

Since Japan has extensive R&D programmes dedicated to energy technology and a noble policy of sharing its knowledge, Malaysia should take advantage of this opportunity and send experts to Japan with the aim of perusing such programmes. Undoubtedly, there will be certain technologies which we should be able to adopt and adapt for our own use.

## Taiwan

The National Taiwan University has already identified several indicators that it uses to measure progress in achieving SD in the Taiwanese energy sector. While Malaysia has already adopted its own set of indicators, a close look at what Taiwan is using could lead to improvements in our own.

Another document titled "Not Necessarily Bottom-Up: Sustainable Development Policy Implementation for Taiwan" presents the process of increasing sustainability awareness used by the Taiwanese. Studying this process could prove to be a useful endeavour for Malaysia as it drives efforts to develop a strong SD culture in the country. Again, it is important to note that the NGTP has already incorporated a number of the Taiwanese approaches; it remains now to fully implement the policy.

## The United States of America

The document titled "Building a Sustainable Energy Future: U.S. Actions for an Effective Energy Economy Transformation" indicates that certain specific actions must be taken in order to source energy sustainably for the future. Fortunately, the NGTP already puts in place a usable framework, as outlined below, to work with whilst heading in this direction.

- A leadership body must be established to coordinate all federal activities related to sustainable energy. The NGTP has already achieved this.
- R&D investment must be increased. This must be done expeditiously by green-technology governance bodies.

- Adoption and commercialization of sustainable-energy technologies must be accelerated. The Green Technology Agency must initiate the associated actions within the RMK10 period.

- Action must be taken at all levels to bolster science-and-technology education in relation to sustainable energy. The Green Technology Agency must initiate an action to bolster STI education within the RMK10 period.

- Global cooperation for sustainable-energy strategies must be fervently promoted while barriers to cross-national collaboration in sustainable-energy research must be brought down.

- Consumers should be kept well-informed of the availability of sustainable-energy products. The public should also be motivated to actively seek out, invest in and implement energy-saving practices and technologies.

While the above points relate to the implementation of SD principles, the USA offers another form of educational expertise on the STI capacity-building front. Many of the top-class American universities have put their course curricula and material on the internet where it is available at no cost! This is a marvelous information-rich opportunity that has all too often been taken for granted. The study team chose to see this as an opportunity to secure complete STI-course curricula from leading universities that can be used to design programmes for specific areas of STI-capacity development. A case in point is the excellent material which the world-renowned MIT places on its website. Valuable information from the site can facilitate the development of specialized STI-course packages which can be made available at our technical universities.

# DEVELOPING STI RESOURCES & CRAFTING SD PLANNING PROCESSES

## Enabling Conditions

The international-experience review in Chapter 8 has identified a number of conditions that must be present in order to successfully develop STI resources (both infrastructure and human capital) and a sustainable-development (SD) plan. There must be at least the following:

- Removal of the various barriers to SD.
- Adoption and consistent enforcement of standards related to energy efficiency and SD.
- A mindset oriented to keeping all options open for consideration.
- Strong and effective leadership in all aspects of the energy sector.
- A clear and effective governance structure for the processes of STI development and SD planning.
- Availability of sufficient financial resources (e.g. funding levels that meet the needs, properly co-ordinated funding to focus on prioritized STI development needs and SD activities, continuous funding over time).

### (1) Removal of Barriers to SD

Developing STI resources and a successful SD plan will undoubtedly require a portfolio of advanced technologies. But such technologies, those available and prospective, are virtually stifled with various forms of barriers, thus preventing them from reaching their full market potential. These barriers include:

- technological barriers (e.g. under-investment in basic and applied research);
- market barriers (e.g. common goods[71] and private goods[72] 'compete' for incentives); and
- institutional barriers (e.g. regulatory, legal and policy constraints).

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[71] In Economics, common goods have the following traits: (1) it is not possible to exclude anyone from its consumption, but (2) its consumption by one person precludes consumption of the same by another. A classic example is that of fish stocks in international waters.

[72] Private goods, however, have the following traits: (1) it is possible to prevent a class of consumers from consuming the good, and (2) its consumption by one person precludes consumption of the same by another. An example would be bread.

If left unaddressed, such barriers will further reduce market efficiency, frustrate policies and drive up costs.

Without efforts to remove or reduce barriers to technology deployment, unsustainable (and certainly unnecessary) high carbon prices would be required to significantly reduce emissions – an effective exchange of one unsustainable pathway for another. However, strong policy leadership (discussed below) that aggressively and systematically eliminates critical barriers to deployment can unlock the full potential of a key-technologies portfolio. It will facilitate reduction of emissions is a much shorter time-frame and at a lower cost, too.

The government will need to review its plans and policies to determine if there are any barriers to developing STI resources and an SD plan.

### (2) Adoption and Consistent Enforcement of Standards

Virtually all studies regarding the successful development of an STI resource base and an SD plan agree that adoption and effective enforcement of appropriate energy-production and energy-use standards is essential.

There will be unique circumstances in each country that require special standards to be developed. But since all countries also face similar problems, extensive work has been done by the International Energy Agency (IEA) and the International Standards Organization (ISO) to create standards that apply to common issues encountered by most countries when they attempt to expand or enhance the STI resource base and articulate a successful SD plan.

A recent IEA workshop helped to provide insight on the requirements and challenges related to energy efficiency and standardization work in a variety of fields[73]. The IEA and the Organization for Economic Co-operation and Development (OECD) predicted that the world energy demand will increase by 45% between 2008 and 2030 if no remedial action is taken. It was said in the workshop that energy efficiency exists but is not easily seen. However, it becomes possible to give visibility to it once metrics are developed. Thus, making energy efficiency visible is the first step to giving it commercial value. Here, technical standards prove their usefulness in allowing efficiency to be defined, measured and evaluated, thus forming the foundation of all actions to reduce energy intensity.

The importance of standardization for energy efficiency was emphasized at the workshop as follows:

> "Today's trends in world energy demand give the sense of urgency. We need to act now with available solutions, which need to be applied and International Standards are part of the solution. ISO, IEC and the International Telecommunication Union (ITU) provide standards that offer performance definitions, measurement and test methods, codification of best practices and management systems, design checklists and guides, interoperability, state-of-the-art knowledge formalized by recognized experts through double levels of consensus, amongst stakeholders and across countries."

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73 These include industrial systems, power generation, buildings, electrical and electronic appliances, networks and data centres, transportation and energy management.

Commenting on the event, the IEC General Secretary and CEO stated that the organization has had a long experience of working on electrical efficiency standards. More electricity needs to be generated, transmitted and distributed but with reduced impact. And electricity would need to be used more intelligently. As the IEC continues to issue the standards needed for existing technologies (e.g. energy efficiency for industrial and domestic uses), it also works on new areas (e.g. ultra-high voltage transmission, integrated smart grids) while continuing to maximize the potential from renewable energy.

The workshop sessions resulted in the following main recommendations.

- Highlight and promote the complementary relationship between public policies and technical standards, communicating clearly that standards provide technical solutions.

- Encourage participation from the earliest stages in the standards-development process of all stakeholders (particularly representatives of public authorities and consumers) having relevant interests in promoting energy efficiency and reducing carbon emissions.

- Improve coordination and optimize involvement of experts in on-going standardization work at the sectoral, national, regional and international levels.

- Ensure that exchange of information takes place and promote the use of existing standards.

In seeing the importance of standardization, it will be instructive for the Malaysian government to visit the ISO information site in order to

- cross check the established Malaysian standards against ISO standards to see if it might be beneficial for any modification so that congruence with its international counterpart is achieved; and

- determine if there already are standards available that could be adopted in respect of energy-related areas Malaysia now considers entering.

In other words, we should do a no-nonsense reality check!

### (3) Keeping All Options Open for Consideration

Since this study presents a framework that is intended to cover four decades, it is extremely important that no energy-related choices be foreclosed. As debates regarding energy options, climate change and sustainability continue, it is becoming apparent that any dogmatic claim about a specific energy option being acceptable or not is a statement of belief and not of fact.

For example, a recent book released in late 2008 titled “Sustainable Energy – Without the Hot Air [74] ” shows that claims on renewable energy (RE) being able to replace fossil fuels and thus create sustainable growth are greatly exaggerated, if not impossible. So when

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[74] Written by David JC MacKay and published in Cambridge by UIT Cambridge.

considering the adoption of RE options, it is extremely important for the government to confirm the viability of how much energy can be derived from the selected RE sources.

Another recent article titled "Environmental Threats to the Survival of the Energy Industry[75]" demonstrates how a number of studies refute the belief that the "emission of sulphur dioxide from power stations is harmful to the environment, and that sulphur compounds should be removed from gaseous wastes before discharge". The author also indicates that it has been demonstrated that reducing sulphur emissions may have negative impacts. So, do we really wish to reduce our dependence on coal or increase it?

A final example is the debate about using nuclear power to reduce GHG emissions. At present there appears to be a significant amount of re-thinking concerning the viability of nuclear power because of its zero-emissions capacity and the progression in nuclear technology with respect to safety.

The message for the government here is to continually consider all options when formulating an SD plan. Ideally, resources should be dedicated to tracking the debates about the various options and to actively search for analyses which attempt to contradict or refute conventional wisdom. This position should be taken so that opportunities potentially suitable for the Malaysian scene will not be overlooked.

### (4) Strong and Effective Leadership

STI infrastructure and human resources (HR) are required to take advantage of the energy-related opportunities already identified in Chapter 6 and to bring them to commercial fruition. As before, the government will have to play a leading role in making sure that such requirements are available. In this respect, governmental activities include:

- Ensuring coordination of the current STI infrastructure and HR base to focus on selected opportunities;
- Identifying where additional or new resources will be needed and motivating the programmes necessary to produce such resources;
- Ensuring that programmes put in place to develop opportunities are monitored to commercial realization; and
- Ensuring that there is a mechanism to continually monitor the energy sector to identify new opportunities.

In short, by taking a strong leadership role, the government can truly ensure that most barriers existing today – human resource shortages, lack of start-up funding, overlapping responsibilities and legal or policy deficiencies – will be effectively addressed. Thus, an environment in which all parties (private sector businesses, NGOs, universities and research institutes, etc.) can make their respective contributions is created.

Specific actions to take in order to exercise *strong* leadership include:

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[75] Written by P. J. Lloyd of the Cape Peninsula University of Technology

- Reducing energy subsidies over a 5-10 year period so that natural gas, petrol and electricity prices are all at commercial levels. The impact of weaning the public off subsidies will be a significant reduction in the liberal use of energy. From the government's standpoint, this will reduce overall national expenditure in the energy sector.
- Adopting new standards and uniformly enforcing all standards, both new and existing.
- Review existing standards to identify those that are irrelevant, inappropriate or biased with a view to removing the aforementioned barriers to development.
- Promoting the view that Malaysia can be a niche player in developing a skill-and-experience base that would support its efforts to become a leading energy player in selected areas (e.g. in solar energy and biomass).
- Assigning specific areas such as (1) energy-opportunity research, (2) development, and (3) commercialization responsibilities to specific universities, institutes and GLCs. In this way, there will be clearly-identified, accountable parties for achieving realization in definite energy-related areas.
- Commissioning PETRONAS University to acquire or develop an energy-specific input-output model for Malaysia so that the government will have a quantitative tool that can be used to explore the impact of prices on economic activity.

### (5) Clear and Effective Governance

Many of the above governmental actions will need to be supported by an effective governance structure that assigns *specific* responsibilities and accountabilities to government ministries and agencies. Such a structure will establish the relationship between universities, research institutes and the private sector. It will also properly allocate lead responsibility for the development of specific sectors of the energy industry. The government has already made significant progress in this area.

### (6) Availability of Funding

Malaysia has already established a number of different funding mechanisms to support STI development and implementation of energy-related technologies. Most of these mechanisms appear to be of a grant nature in addition to some tax schemes. However, there does not appear to be a coordinated effort to ensure that the projects being funded truly operate in support of one another to maximize the value derived from money spent.

The government should consider establishing innovative funding mechanisms to accelerate adoption and commercialization of new energy-related technologies as new businesses. Some suggestions of such mechanisms are as follows.

### *(6.1) Grant programmes*

Government grant programmes to fund R&D could include a provision that if the R&D leads to commercial products or services, those benefiting from such commercialization would be required to repay a portion of the R&D cost initially covered by the grant (e.g. 50% or 75% of the grant over a defined time period). Companies benefiting could be granted a monopoly during the period of repayment.

### *(6.2) Revolving fund*

A revolving fund would provide financial assistance to help defray the initial cost of adopting new and improved technology. Funding provided would be recovered over a defined period of time from the extra returns the investor makes as a result of reduced operating costs and energy savings.

Existing government funding must be centralized into this revolving fund with its own independent board of trustees. An independent board will ensure that the allocation of funds will be based on technical competence and priority levels of energy-related opportunities. The board would be responsible for allocating funds to universities, institutes and GLC R&D efforts. Thus, the board would be expected to evaluate each opportunity and select those that (a) meet the right time-frame, (b) are most likely to attract other funding to assist with further development, and (c) provide the greatest contribution to the country's energy-sector development.

A certain float (say, 10-15% of the revolving fund) should be reserved so that the board could consider new applications. Repatriation to the fund is needed to complete the cycle. So, any funding of opportunities should carry a requirement that the recipient be obligated to repay the fund through a pre-determined share of any savings realized.

In order to achieve the independence needed in the administration of the fund, the study team suggests that ASM be responsible for assembling a competent and independent board.

### *(6.3) Green energy tax*

To increase the funding available for these energy-related opportunities, a "green energy" tax dedicated to the "Green Technology Fund" should be imposed. This tax should incorporate the "polluters must pay" concept. The main purpose of such a tax would be to show potential funding organizations abroad that the country is serious about sustainable-development efforts. This will enhance the chances of receiving additional funding. This approach has been used successfully by South Africa.

### *(6.4) Tax schemes*

Since Malaysia already has taxation laws in which accelerated depreciation[76] on new or additional investments would be allowed, it should use this structure in relation to new energy-related technologies. Other forms of tax relief can also be developed.

[76] In tax, accelerated depreciation (or capital allowance, as it is called in Malaysia) provides a way for deferring tax by reducing taxable income in current years (i.e. reduced cash outflow) in exchange for increased taxable income in future years; it is thus a form of incentive for businesses to purchase new assets.

# NATIONAL PLANS & STI CAPACITY BUILDING

STI-related national plans were last reviewed in Chapter 6 in which a summary of the strategic thrusts from each plan were presented. However, it was argued in that chapter that such plans were flawed primarily in their failure to implement measures designed to build a strong STI resource base in the country.

The study team now presents several recommendations in relation to such plans.

## The Knowledge-Based Economy Master Plan (2002)

The recommendations in the K-based Economy Master Plan are very similar to those in the plans currently being prepared by MOSTI (the STI Strategic and Action Plan) and MOHE (the National Higher Education Action Plan). Since the two later plans practically address the same issues as the earlier K-based Plan, MOSTI and MOHE should use the K-based Plan as a reference check.

Additionally, MOSTI and MOHE should carefully review what has `actually happened since the formulation and supposed implementation of the K-based Plan. By identifying the reasons for implementation failure, the country can better deal with the causes of such failure and thus prevent a recurrence. If this learning exercise is not undertaken, the full potential of all future 'well-meaning' plans will never be realized.

## The National Higher Education Action Plan (2007-2010)

The study team observes that the current level of competence in the country's technical universities must be significantly strengthened. One bold suggestion worth considering is to transfer all basic and applied (up to pre-Commercialisation) research activities of such institutions to MOSTI with MOHE retaining its role as the overseer of all universities in the country. With direct control over R&D&C content, MOSTI would be in a strategic position to facilitate R&D&C efforts that are most relevant to STI development while MOHE continues to ensure that stipulated academic and performance standards are met.

MOSTI and the MOHE should also consider pairing research institutions with technical universities. The curricula should be altered so that it becomes mandatory for science and engineering students to pursue specific courses in each other's disciplines. This move would (1) holistically improve the ability of both scientists and engineers to commercialize R&D results, (2) create more opportunities for academic development through work on practical, real-life projects, and (3) provide competent low-cost research staff for institutes.

### MOSTI Strategic and Action Plan (2010-2020)

This MOSTI Plan is of very high quality and contains all the elements needed to significantly enhance the STI resource base of the country. In order for MOSTI to deliver on its promise entailed by the plan, it will need to be the lead organization for STI development. MOSTI will thus have to coordinate very closely with KeTTHA in order to identify the most immediate STI-priority needs to be addressed.

Finally, the study team reiterates the need to make changes in the university-education system so that MOSTI is given a stronger role for all tertiary-education processes linked to STI capacity building. As indicated earlier, MOSTI must also review the earlier plans that have not produced the deliverables that were promised. With this corrective action, MOSTI can be more assured of success in the implementation of its brand new plan.

# OIL & NATURAL GAS

Despite the fact that the Kikeh oil field has brought new supplies of oil on-stream, the country is set to become a net importer of oil by 2014. Added to this is the fact that local gas supplies are depleting and are uncertain beyond 2019. These considerations have led the study team to make the following recommendations:

- Rejuvenate mature oil fields using EOR techniques to realize a further 5-10% increase in the recovery factor.
- Develop small and marginal oil fields.
- Intensify exploration to find new oil fields in deeper and frontier areas.
- Develop small and marginal natural gas fields.
- Re-evaluate exploration data pertaining to gas reservoirs with a view to rejuvenating those that are now defunct.

# RENEWABLE ENERGY

The study team recommends that the government highlight the following areas to be considered as the main agenda in the next *ASEAN New & Renewable Energy* meeting.

- Review the current RE policies in each ASEAN country.
- Review the current RE incentive and support structure in each ASEAN country.
- Identify the obstacles and barriers faced in implementing RE projects. (Chapter 6 provides a nearly exhaustive list of these.)
- Identify RE technologies and establish partnerships to promote these.
- Establish standardized RE policies for ASEAN countries.
- Encourage all ASEAN countries to be proactive in implementing RE schemes with immediate effect.

## Establishment of a Special-Purpose GLC

Since the country has to be looking at the development of alternative multi-energy sources, a reasonable question to be asked is, "What is the most cost-effective way for Malaysia to do this?" The study team is aware that the country has had success with GLCs being given responsibility for developing specific areas. The idea here is to establish a new company to be responsible for researching and developing a defined package of alternative energy sources. The initial list of 'candidates' could include:

- Solar photovoltaic energy;
- Large hydroelectric power;
- Geothermal energy (in Tawau, Sabah, and neighbouring countries);
- Coal-bed methane;
- Underground coal gasification;
- Ocean (tidal, wave and thermal energy conversation – Sabah Trough);
- Bio-diesel (from sources other than palm oil); and
- Biomass.

The recommendation of the study team is the setting up of this company as a wholly-owned subsidiary of PETRONAS. Such a recommendation is being made for several reasons.

- PETRONAS has a strong STEI (science, technology, engineering and innovation) resource base.
- PETRONAS could commission the relevant R&D to be carried out at its university.

- PETRONAS already has a unit that is analyzing alternative energy resources.
- PETRONAS has the resources necessary to provide both the initial funding as well as the administrative structure to run this company.
- PETRONAS has a huge bank of experience in dealing with suppliers, vendors, developers and investors.
- PETRONAS has a track record as a very successful MNC.

This subsidiary would have its own charter, management and staff. The subsidiary's objectives and focus would be jointly defined by the government and PETRONAS. Oversight, the monitoring of progress and the 'push' towards commercialization would be the responsibility of PETRONAS.

The study team believes that this approach would be a much more cost-effective way of researching and developing alternative energy sources than merely leaving this to the market. Malaysia is a small country with limited resources that need not be wasted by funding a variety of alternative proposals at the same time. The subsidiary company would have the competence to screen multiple proposals, identify those that look promising, then establish an appropriate commercial relationship with the chosen parties that will ensure success for each energy project.

### Develop Malaysia's Solar PV Potential into a Major Industry

Since Malaysia already has a position in the PV manufacturing industry, this opportunity focuses on expanding this position to become a major industry penetrating international markets. The study team believes that this transformation can occur over the next 10 years.

Looking first at the benefits to be realized from developing the PV industry, it has been estimated that such a development would consist of:

- The establishment of a new technology sector with high-growth potential possibly providing 100,000 jobs cumulatively by year 2020;
- Making Malaysia one of the world's top five PV-equipment-manufacturing countries with a possible global manufacturing share of 10%. This would generate a cumulative revenue of more than RM560 billion by 2020, of which 50-70% of the value would go directly to the local industry; and
- Providing direct benefits to local industries that will be worth an estimated RM280 to RM400 billion depending on value chain of the products.

It is estimated that the cumulative revenue from the PV industry could contribute up to 4% of the National GDP by 2020.

In order for Malaysia to capture a 10% share in the global PV manufacturing industry, an estimated RM250 billion would be needed from 2010 to 2020. This amount would also stimulate the local economy as most of the money would be spent locally.

This cumulative cost includes direct and indirect investments (for example infrastructure, capital expenditure, R&D, industrial programmes, etc.) and should be shared amongst the MNCs (about RM100 billion), the industry (about RM73 billion), the government (about RM57 billion) and other related stakeholders (about RM22 billion). Nevertheless, the cumulative direct benefits to the local industry generated by 2020 would outweigh the costs by 130% to 160%, even without considering the impact of the business revenues from the PV industry.

The study team recommends that the government establish a National PV Industry Development Programme to address the following issues.

### Industry Enhancement

- Create coordination between various government agencies for PV-industry development.
- Intensify human capital development, for example, focusing on industry missions, sponsored exchange programmes such as apprenticeships, and international training.
- Facilitate partnerships between MNCs and the local industry.
- Upgrade targeted local industries to PV business (for example wafer fabrication, electronics) as this presents lower costs, lower entry levels and faster implementation.
- Introduce industry quality and award schemes as well as demonstration programmes.

### Infrastructure

- Introduce business facilitation packages (e.g. soft loan schemes, focus grants) for local industry to enter and expand in PV business.
- Promote IP acquisition and FDIs with focus on direct benefit for the local industry (thus triggering domestic direct investments).
- Identify government or GLC investments in new promising PV technologies and catalyze the development, incubation and creation of fast spin-offs.
- Establish internationally recognized test facilities and a PV R&D center to support the R&D activities that will be required.

### Research, Development and Innovation

- Design and implement a national PV R&D roadmap (with focus on technology innovation and cost reduction).
- Establish a review and advisory committee (with local and international experts).

- Increase the R&D budget for PV technology and processes with constant monitoring and feedback from the industry.
- Enhance industry collaboration with academics.
- Exploit the brain gain programme (with a special focus on PV technology) and foster technopreneur growth.

### Conducive Market Environment

- Introduce a Renewable Energy (RE) Law which includes a Feed-in Tariff (FiT) mechanism with specific National RE targets.
- Implement a cost-sharing mechanism via the RE Law (by creating a RE Fund) to offset the incremental cost of the FiT.
- Implement regulatory conditions for grid-interconnection via the RE Law, for example, access to the national grid.
- Promote public awareness and implement advocacy programmes.
- Install PV systems in government buildings and promote Green Building Index (GBI) compliance.
- Design a long-term national energy plan based on RE and solar energy.

In addition to addressing the above issues, the programme will need to establish a dedicated team in a central agency with the right competencies and strong expertise in all aspects of the PV industry. This agency should be empowered to undertake coordination activities in a transparent and unbureaucratic manner and be accountable to the highest levels of the government on a periodic basis.

# NUCLEAR POWER

## A Framework for the Development of Nuclear Power

The government has already made a decision to include nuclear power in the national energy mix. However, studies need to be taken to confirm five key sustainability considerations:

- The safety of power-plant operations;
- The security of power-generating stations;
- The certainty of nuclear fuel supplies;
- The safe disposal of nuclear waste; and
- The management of potential "meltdown".

There remains the question of economic viability. The cost of building a single nuclear power station is extremely high. At present it appears that in addition to Malaysia, Thailand, Vietnam and Indonesia are also considering the development of nuclear-generation facilities. If each country proceeds on its own, each is likely to have to pay the maximum price for the construction of a single nuclear power unit and incur the full cost of training plant operators, maintenance, refuelling and safety procedures.

The study team proposes that the government set up a Special-Purpose Vehicle (SPV), jointly owned by the four countries, for the purpose of developing, operating and maintaining one plant in each country. It is believed that this SPV scheme would bring economic advantages to all four countries, as follows.

- The ability to plan the sequence in which the plants will be built in accordance with each country's needs. For example, Malaysia currently has excess energy capacity so it would prefer to build later.
- The ability to contract for four plants at once, thus being in a position to negotiate for discounts.
- The ability to contract for four plants of the same design so as to standardize maintenance procedures, training of staff and storage of spares and ancillary equipment.
- The ability to secure fuel supplies for four plants from one supplier hence reducing fuel-procurement costs.
- The ability to coordinate outages when routine maintenance is being performed. This move will cushion the impact of such outages on the generation-reserve situation in the four countries.
- The ability to centralize support resources such as finance, HR, procurement, etc.

It has already been proven in the USA that this is a workable concept. Exelon and Entergy are two companies that have taken over a number of individual nuclear-power plants and are now managing them on a group basis. This model significantly increases the utilization of each plant, reduces operating and maintenance costs and extends plant life.

The downside of Nuclear (fission) Power Plants (NPP) however should be considered in any plans to develop. They are:

- No one can guarantee accidents will not occur
- Any breakdown will affect large residential and high-density industrial areas
- Breakdowns would take time to rectify, and
- Serious health hazards need to be considered

Due to the enormous cost of setting up a nuclear-power plant, the study team encourages the government to seriously consider exploring the Special-Purpose Vehicle (SPV) concept.

In the interim period, Malaysian researchers should be sent overseas for technological-transfer attachment in nuclear fusion technology. Furthermore, as R&D intensifies in renewable energy (solar, wind, bio-mass, biofuels, Ocean Thermal Energy Conversion (OTEC) etc), this sustainable form of clean energy will become viable economically in 20 years' time.

# BUILDINGS

## The Refrigerant Industry

The reader will recall that in Chapter 7, the case for switching to hydrocarbon (HC) refrigerants in the air-conditioning and refrigeration industries was clearly presented. This included all residential, commercial and industrial applications. It was also pointed out that HC refrigerants can be produced from natural gas.

The study team recommends that this switch be carried out on a nation-wide basis in a process that begins with the support of PETRONAS. The country's entire supply of HC refrigerants can be produced locally using natural gas supplied by PETRONAS. In this way, we can meet all our refrigeration and air-conditioning needs at the prices we once paid for the now banned CFCs.

The equipment targeted for this change would be domestic refrigerators, split-unit air-conditioners, unitary expansion air conditioners and chillers.
For ease of discussion, the estimated 7 million automobile air-conditioning units are also included here.

It is envisaged that it will be possible to effect the abovementioned change within 3 years for all new automobile air-conditioners, domestic refrigerators and split-unit air-conditioners. A 5-year time-frame will be required for other applications.

The potential savings to be realized by converting to HC refrigerants are significant. These will be:

- Savings in foreign exchange since the raw material would be locally-derived natural gas;
- Savings in energy consumption during use of the equipment; and
- Savings in energy consumption during manufacture.

Figure 8.3 shows the estimated annual consumption of conventional refrigerants that are currently in use. (As intimated earlier, the figures for the automobile air-conditioning industry have been included in this discussion on buildings.)

| | Thousands of kg | |
|---|---|---|
| **Year** | 2008 | 2010 |
| Automobile Air-Conditioning Replacement | **3,150** | **3,660** |
| New Automobile Air-Conditioning | **580** | **680** |
| Refrigeration Replacement | **12** | **13** |
| Commercial Refrigeration | **14** | **14** |
| New Domestic Refrigeration | **56** | **62** |
| Air-Conditioning Services Replacement | **150** | **150** |
| New Air-Conditioning | **130** | **160** |
| Total | **4,092** | **4,739** |

Figure 8.3: Estimated Annual Consumption of Conventional Refrigerants

Source: Ir TL Chen, 2010

Import data show that in 2006, the country procured 4,562 thousand kilograms of the refrigerant R 22 (an HCFC) from abroad. This has long been the refrigerant of choice for split units, direct-expansion air-cooled units and water-cooled units nation-wide. Such units form the bulk of the equipment used in refrigeration and air-conditioning. Based on the above figures, the estimated annual cost of imported refrigerants has easily been in excess of RM 200 million.

## Energy Standards for Buildings

The study team recommends that the following actions be taken for buildings across the country.

- Enforce minimum energy standards for new buildings which will be constructed within the next three years. This would be the simplest immediate measure to reduce energy usage in the *long* term.
- The same standards should be maintained when retrofitting existing buildings. It is worth noting that many buildings in the country are reaching the 30-year mark in terms of age and are thus ripe for retrofitting or replacement.
- The implementation of the Malaysian Standard (MS 1525) on Energy Efficiency[77] continues to be delayed. An immediate approach would be to enforce compliance with the industry-driven Green Building Index (GBI) which effectively addresses all the key aspects of MS 1525.

[77] A code of practice, with SIRIM as overseer, on energy efficiency and renewable energy for non-residential buildings.

- Enforcing full compliance with MS 1525 for all new and existing buildings of GFA [78] less than 4000 square metres of air-conditioned space within the next 5 years before raising any benchmarks. This would involve achieving desirable OTTV [79] and RTTV [80] values.

- Extending the above to buildings of all sizes within 10 years.

- Raising the current EE benchmark for all equipment that is used extensively nationwide. Good 'targets' for this move would be all direct-expansion unitary air-conditioners. This should be done within 5 years. (It is known that chillers have higher EE than unitary units but the country currently uses more of the latter.)

- Setting up R&D facilities such as test laboratories to seek to increase EE figures for unitary units. These facilities should run for the next 10 years.

- There is an urgent need to establish a wider base of energy-performance data through a centralized agency that would coordinate all current and future strategies as outlined above. For example, this agency's role can be brought to bear upon the ongoing application for GEF[81] grants to carry out more BEI data-acquisition activities. It cannot be denied that more comprehensive data are vital for the setting of higher EE targets.

- The provision of tax incentives to cover a five-year period with effect from October 2009 for all GBI-rated buildings will certainly promote EE in the design and operation of such buildings. This initial impetus should be followed by mandatory BEI targets for these buildings from 2015.

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78 Gross floor area

79 Overall thermal transfer value – a number indicating the total rate of transfer of heat energy into a building.

80 Roof thermal transfer value – a number indicating the rate of transfer of heat energy into a building through the roof.

81 Global Environment Facility – an independent financial organization that provides grants to developing countries for projects addressing global environmental issues

# TRANSPORTATION

## Electric Vehicles

The government should send out strong signals that it will favour cleaner vehicles over those using oil and gas. One way to do this is to review the *National Automotive Policy* and weave these signals into it. This will prompt industry players into making a definite start. The R&D aspect should be given strong impetus whilst monitoring the developments worldwide.

Unfortunately, electric cars face higher entry barriers. For one, the cost can be as much as twice that of petrol-engine cars. Therefore, at the initial stage, the electric car should be supported with various financial incentives to place it on an even playing field with conventional vehicles. These incentives could be an extension of the existing *Industrial Adjustment Fund* through which Malaysian automobile manufacturers and assemblers receive grants or other financial assistance for R&D or machinery-upgrade exercises.

In the short term, a good approach would be for the government to impose a 'carbon tax' which would make owning a petrol-based vehicle more expensive than a zero-emission one. The current taxes imposed on vehicles through licenses and sales duties could be based on the extent of carbon emissions. The overall thrust of the regulatory framework should be to penalize vehicle emissions thus raising the cost of conventional cars.

## Public Transport

Undeniably, the country's current public transport system is grossly inadequate and is clearly unable to meet the needs of the travelling public. To date, the system has been notoriously known to be:

- Unreliable – vehicles seldom run on schedule;
- Inefficient – travel times are unnecessarily long; and
- Dangerous – especially on long-haul routes.

This state of affairs, brought about in part by relatively low fuel prices (due to subsidies) and a wide network of roads and highways, has made private cars the preferred mode of transport for the middle class. As a result, only about 16% of the working population currently relies on public transport.

The extensive dependence on private vehicles has made the transport sub-sector a major contributor to air pollution in the form or particulates (soot) and greenhouse gases (GHG). With the impact of climate change now being increasingly felt, this can no longer be ignored.

### A Four-Pronged Integrated Approach

Against a backdrop of increasing population and growing affluence accompanied by the need for greater personal mobility, the study team is recommending a four-pronged integrated approach to solving the transport problems in the country

### *(1) A Modal Shift that Promotes Lower Fuel Consumption*

An efficient public transport system will go a long way towards reducing fuel consumption and minimizing the emission of GHG. Therefore, the promotion of a safe, reliable, efficient, coordinated and integrated urban passenger system, managed in a reliable way to ensure improved levels of mobility and accessibility, should be given serious attention.

#### *(1.1) Mass Transit Systems*

Mass transit systems, by definition, move a large number of people in groups over fixed routes. Such systems are more cost-efficient and less environmentally harmful than personal automobiles. Therefore, governments all over the world are focusing efforts on making bus and rail transport the preferred choice for the city dweller.

Such systems are advantageous from a fuel-efficiency perspective. For the same distance travelled, a sole occupant in a car uses eight times more energy than a person on a bus, and twelve times more than a light-rail transit commuter.

The government is well aware of the crucial importance of developing a well-functioning public transport system to improve mobility whilst alleviating congestion and minimising fuel costs. Measures that were to be taken during the Ninth Malaysia Plan (2005-2010) hoped to achieve a public-to-private transport ratio of 30:70 by 2010. This was to be done in the Klang Valley through the expansion of the LRT and Commuter services with more stations, the procurement of more rolling stock and buses, and the establishment of more "park and ride" facilities. In addition, integrated transport terminals were to be constructed as transit hubs to enable inter-city passengers to access the central areas of Kuala Lumpur by urban rail systems.

This, however, has been slow in its implementation. The 30:70 ratio has been revised to 25:75 and the year of completion from 2010 to 2012. A special commission established to oversee the transport objectives of the Ninth Malaysia Plan in the Klang Valley is now expected to be convened only in 2010.

Increasing the network coverage and the passenger-carrying capacity of the LRT and Commuter systems in the Klang Valley to become comparable with Singapore's acclaimed MRT system should be made a priority. As more people are encouraged to use rail-based transport to and from work, it is important to ensure that the enhanced system runs efficiently, failing which these passengers will simply revert to their "good old ways'' of using private transport.

There are, however, inherent inefficiencies in MRT systems. For passengers, these include time wasted waiting for the next arrival, indirect routes to their destinations, stopping for passengers with other destinations, and often being misled by confusing and inconsistent schedules. For the rolling stock, accelerating and decelerating heavy objects consumes huge amounts of energy – this can somewhat offset the cost-effective advantages.

One recent development in public transport is the *personal rapid transit (PRT)* system. Such a system moves small groups of people non-stop in automated vehicles on fixed tracks. Passengers can, in theory, board a pod immediately upon arrival at a station, and can – with a sufficiently extensive network of tracks – take relatively direct routes to their destination without stops. As it stands, PRT now remains a potential rather than a proven reality. Thus, while the government continues to expand the capacity of the existing rail-based systems, prompt consideration should be given to developing the PRT concept in new urban areas such as the country's five development corridors.

An exciting STI opportunity associated with PRT is the use of solar energy as a viable power source. PRT elevated structures could provide a ready platform for solar collectors. As such, only those designs that include solar power as a characteristic of the network should be allowed in this country.

#### *(1.2) Introduction of Bus-Ways*

Restricted bus-ways should be constructed on the outside or on the centre lane of major arterial roads. This will allow unrestricted movement of buses thus improving reliability in terms of arriving at designated destinations on schedule. This, in turn, will encourage wider use of public transport. This is a cheaper option than the construction of LRT lines which require huge capital outlays of about RM150 million per kilometre. The gestation period is also much shorter.

The Trans-Jakarta Bus Way in the Indonesian capital is a classic example of a successful Bus-Rail Transit (BRT) system and a boon to commuters in a city that is caught in a perpetual traffic gridlock. Bangkok has also recently started the construction of a 15-kilometre dedicated bus route alongside its MRT system.

#### *(1.3) Bigger-Capacity Urban Trains*

The proposed Kota Damansara-Cheras line should be designed as an MRT rather than as an LRT system. The former is capable of 8-12 cars per trip as opposed to the latter's 2-4. This translates into 3 to 4 times the number of passengers per direction per day.

The above measures will surely result in more business opportunities as investors, together with their R&D experts, find ways and means to adopt and adapt proven transport systems and technologies to the Malaysian scenario.

### *(2) Improving the Efficiency of Vehicles*

#### *(2.1) An Increased Share of Diesel-Powered Private Vehicles*

Diesel vehicles, which traditionally have not been well received due to visible exhaust smoke and ultra-fine particulate emissions, are rapidly gaining popularity. This is evident from the increasing proportion of diesel-powered private vehicles being sold in Europe.

Diesel contains 18-30% more energy per litre than petrol. Furthermore, the diesel engine can 'boast' of lower GHG emissions than its petrol-powered equivalent. Diesel-engine technology has grown by leaps and bounds over the past decade. Engines that use diesel with an ultra-low sulphur content generate emission levels comparable to that of the best petrol engines and with a higher fuel economy to boot. Many new vehicle technologies also contribute to lower fuel consumption and GHG emissions. Some of these are: reduced vehicle weight due to lighter materials; smaller aerodynamic drag due to new structural designs; turbo-charging engines; light-weight alloy engines; light-duty hybrids; tyres with low rolling resistance; low-friction lubricants; idle-stop features; variable-valve control; variable compression ratios; and advanced air- conditioning technology. Staying mindful that 99% of the Malaysian private vehicle fleet currently uses petrol, these are excellent STI opportunities that local car manufacturers should exploit.

The government has taken the first step. In order to encourage the use of diesel-powered vehicles, it announced in its Budget 2009 that the road tax of such vehicles be reduced to the same level as that of petrol-powered vehicles.

### *(2.2) Adopting Higher Fuel Economy Standards*

Hitherto, there are *no compulsory fuel economy* standards imposed on newly manufactured or imported vehicles in Malaysia. Consequently, there are also no data available on the average fuel economy of vehicles currently in use.

The government should make it mandatory for newly manufactured or imported passenger vehicles to comply with prescribed fuel economy standards. In this area, we should follow the lead set by other countries. In the USA, for example, the *Corporate Average Fuel Economy (CAFE) Act* determines the minimum acceptable standard of fuel economy for all average-sized vehicles. The figure has been set at 9.7 kilometres per litre (27.5 miles per gallon). The US Congress is considering raising this to 12.4 kilometres per litre (35.0 miles per gallon) by 2020. Other countries which have regulatory standards are Japan, China and South Korea. The European Union and Australia have voluntary targets worked out by consensus with vehicle manufacturers.

It must be acknowledged, however, that there will be a substantial time lag between the imposition of standards and the fleet-wide improvements that are expected to ensue from them. This is because such standards can reasonably be imposed only on new vehicles. Since the average useful lifespan of a petrol-driven sedan is 13 years (and longer still for diesels), *the imposition of tough standards today will register a full payoff only in the next decade.*

One of the most effective ways to conserve energy, particularly in view of our depleting oil reserves, is for the government to impose higher fuel- efficiency standards on all new vehicles. The government could go one step further. To encourage the production of fuel-efficient vehicles, it should consider providing incentives to local manufacturers and assemblers to install more fuel-efficient engines in their vehicles.

It is imperative that fuel economy standards be imposed upon our national car manufacturers. This will compel them to strive for more energy-efficient designs that will in turn make their vehicles more marketable internationally. Prior to the imposition of such standards, the government can provide the impetus towards higher fuel efficiency by announcing fiscal incentives to manufacturers. A novel way of doing this is to award “feebates”. These are *fees* imposed for not meeting standards and *rebates* for surpassing them.

The government should also doggedly pursue its current practice of progressively removing all fuel subsidies. When this happens, fuel prices will be determined by market forces. Eventually, astronomical fuel prices will drive customers to demand fuel-efficient vehicles. This will compel manufacturers to vigorously pursue fuel-efficient technologies.

As alternatives to the imposition of fuel-economy standards and the removal of subsidies, the government could consider

- the imposition of taxes that rise exponentially with engine capacity; and
- levies on fuel prices at the pump to reflect the hidden cost to the environment.

These are definite ways of driving customers to demand more fuel-efficient vehicles and compelling manufacturers to respond accordingly.

## *(3) Changing to Fuels with Lower GHG Emissions*

### *(3.1) Hybrid Engines (Petrol and CNG)*

The government's promotion of the use of natural gas (methane) as a substitute for oil in the transportation sector should be continued. Natural gas produces one-third less GHG emissions than petrol. Currently, there are only about 27,000 vehicles (mostly taxis) that have been specially fitted at considerable cost to run on either natural gas or petrol.

Natural gas vehicles (NGVs) are not popular in spite of lower fuel prices due to the hassle of finding filling stations and the long queues at these facilities. At the moment, there are only 120 stations nation-wide providing this service. The number is expected to increase to 200 by the end of 2011. However, NGVs need more frequent fill-ups as they typically travel 125-150 kilometres per 50-litre tank as compared to 300-425 kilometres per 30-litre tank for petrol-powered vehicles. Hence, demand for NGVs will grow only if there is easy access to a much wider network of filling stations.

The government's provision of grants of RM50,000 per vehicle to bus operators who buy new mono-gas NGV buses before end-2008 is another encouraging move. Taking the cue from the government, local car assembler Naza will roll out hybrid-engine prototypes of the Naza Ria and Naza Citra that can be powered by natural gas or petrol. The government should consider re-introducing the grant provision to encourage more bus operators to switch to NGVs.

### *(3.2) Use of Bio-Fuel*

This subject was already treated in Chapter 6. The recommendation from the study team is that the government continue this initiative and expand on it.

## *(4) Urban Design that Reduces the Need to Travel*

### *(4.1) Less Passenger-Kilometres or Freight-Kilometres*

Urbanization means more people will be living and working in cities, making more trips, often over longer distances. This development approach has profound effects on the transport sector. The growth of cities without adequate planning and control means more travel and fuel consumption. At some point, growth becomes unsustainable.

A long-term option is to integrate the planning for transportation and land-use in such a way as to reduce energy consumption. The goal is to design and build transport-smart cities in order to reduce commuting distances and trips made by passengers.

With this smart approach, the shape and design of new urban and development areas can be controlled so as to render them efficient in terms of transport usage and fuel consumption. Zoning and development policies that encourage high-density housing and well-mixed residential, retail and business areas can dramatically reduce the number and length of trips taken in private vehicles. Such policies can also help to ensure that future development is amenable to more efficient transport modes such as public transit, walking and bicycling.

A classic example is the city of Curitiba in Brazil where the local authority has developed an integrated scheme for transport, urban planning, infrastructure, business and local community development. By planning and zoning residential and industrial development along so-called arteries in proximity to public transport, the need for people to move around has been managed sustainably.

In the development of new commercial and housing estates, the government should have a regulatory framework that minimizes traveling to and from the workplace. Working hand in hand with the private sector, an effective infrastructure network can be put in place such that there will be little need for private cars. Mass transit will then be the popular choice amongst the majority of the population.

A system needs to be worked out in which, as far as is practicable, employees stay as close as they can to their workplace so that traveling distances can be minimized. With more effective and efficient use of internet services, the government and the private sector can make it mandatory that some of their non-frontline employees can work at home at least once a week.

In order to realize all of the above, the development of economically feasible systems and technologies will be necessary. Smart R&D partnerships with industry will be one option to lower the cost of alternatives. The government's *five development corridors* will be ideal places to implement some of these measures.

### *(4.2) Green Energy Communities*

The 'think green' concept should, in the near future, be the overriding theme in new commercial areas and townships where it is implemented. This should be done as extensively as possible so that we will see green offices, green buildings, green residential units, green universities and entire green communities. Such communities would serve as role models in the production and use of 'clean' energy.

These green communities will be the nuclei from which smart networks will develop into nation-wide realities. A transformed energy system will provide the impetus for the large-scale development of numerous low-carbon technologies. The green communities would become the champions of energy efficiency with electric vehicles plying the streets. Internal combustion engines would run on renewables such as biomass-derived fuels produced within the buildings.

To realize the existence of such green communities, a smart public-private partnership needs to be developed between the government and the property developers. This partnership will open up a plethora of new, exciting and innovative windows of STI opportunities.

### *(4.3) Integrating National Transport and Energy Policies*

For Malaysia to move forward in the implementation of such grand schemes, holistic planning must become the order of the day. Priority must be given to formulating an integrated national-transport-and-energy policy. This policy must supercede all others, and all actions to be taken will have to be "in sync" with the objectives of this policy. It is imperative that the policy be formulated on the principles of sustainable development. It must have a forward-looking R&D agenda, with specific targets and timelines for achieving energy efficiency and emissions reductions. The specific details of such a policy are beyond the scope of this study.

# CHAPTER NINE

# The Energy Roadmap, the Action Plan and the Rollout Programme

Figure 9.1 summarises how the concepts of an energy roadmap, an action plan and a rollout programme tie in with each other. A roadmap spells out in broad terms what a nation wants to do or 'where' it wishes to go. The roadmap presented here has been dubbed a "Green Technology Roadmap" because the stated intention of the Malaysian Government is to inculcate the 'green' concept into everything we do as a nation from here on in. An action plan comprises elements that define the planning processes as well as opportunities that can be pursued and driven to commercialization. A rollout programme identifies actions from a prioritized list that can be taken in the immediate term.

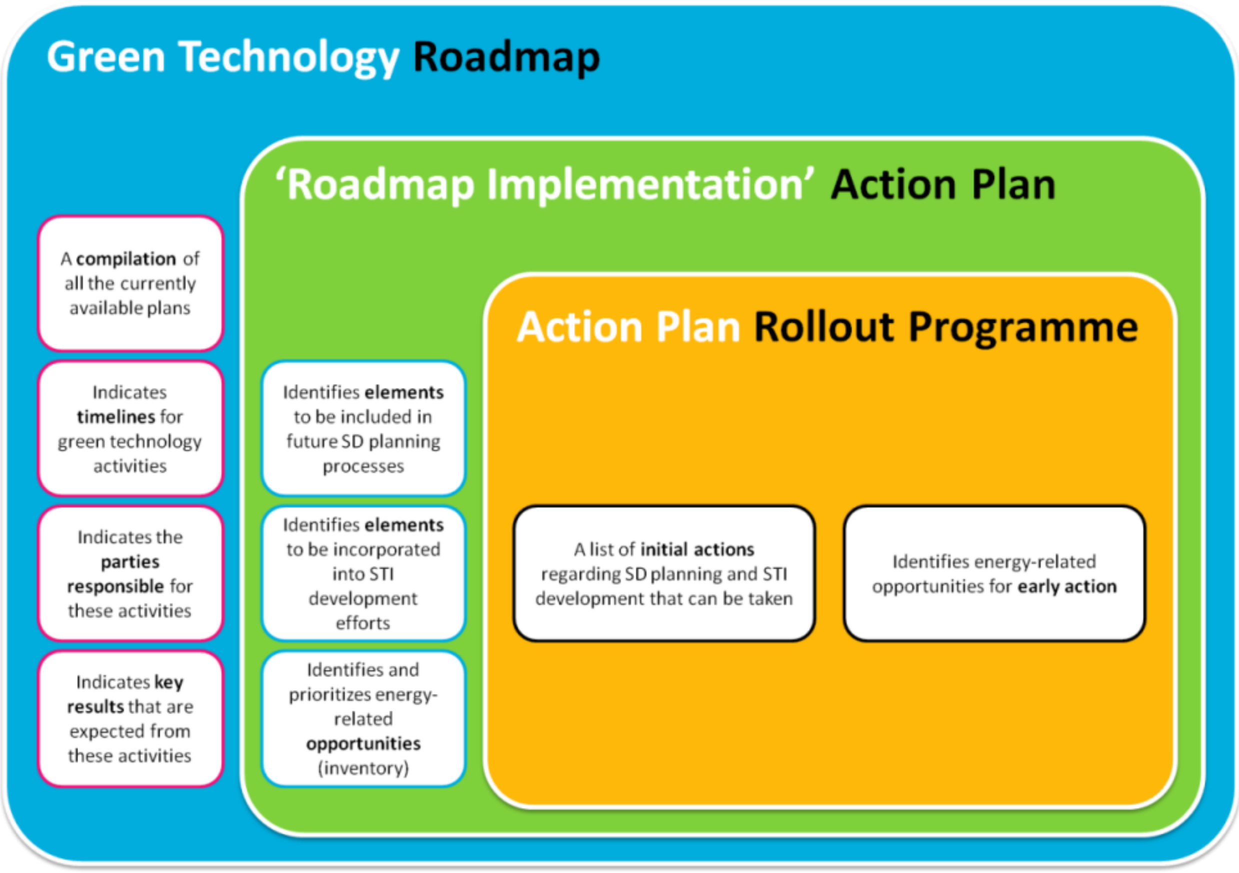


Figure 9.1: The Relationship Between A Roadmap, An Action Plan and a Rollout Programme

# THE DEVELOPMENT OF A ROADMAP

The study team has not attempted to create an energy roadmap for the country. This is because it is in no position to do so. Instead, the team has already made strong recommendations in Chapter 8 with respect to the Green Technology Council and the Green Technology Agency. The team believes that these two bodies should be given the mandate to map out the country's energy future.

What follows, hence, is a mere *description of a roadmap development process.* The discussion is merely *illustrative* and the ideas expressed have a validity that is contingent upon the reader's acceptance of the high-level framework that was presented at the head of Chapter 8.

Once a high-level framework has been established (this has already been accomplished with the adoption of the NGTP), the first action of the Green Technology Agency must be to initiate the development of the roadmap that will integrate all the plans/policies that the government currently has or is developing. With this, the Green Technology Council can then use the roadmap to coordinate and prioritize all its energy-related initiatives.

To date, the government has formulated (through its ministries and agencies) more than 14 separate plans and policies that deal with sustainable development (SD), STI capacity building and the identification of energy-related opportunities. Alas, these plans and policies show minimal cross-reference to each other. It is painfully apparent that each planning group went about its work as if the others did not exist. The status quo is that the national planning effort is heavily fragmented and continues to this day in separated silos!

Given the lack of integration of all these sincere but nonetheless uncoordinated efforts, the roadmap-development process requires a detailed review of every single one of these plans and policies. For each plan or policy, the review must identify:

- The areas covering energy, SD and STI development and the associated actions proposed for each.
- The degree to which the plan or policy relied (or still relies) on input from any other plan or policy.
- The degree to which a sector or specific area addressed in the plan overlaps or duplicates that of other plans or policies.
- The implementation time-line for every one of the actions proposed.
- The resources (both human and financial), whether currently available or planned, to carry out the actions proposed.
- The level and nature of effort to be devoted to STI-resource development.

The intended outcome of this review should be a *single* document that provides the Green Technology Council with the following *information*:

- A summary of the main points from each of the plans or policies formulated by the government. Only then would there be a single reference point that describes all the major planning activities completed or currently underway.

- A determination as to whether a plan/policy overlaps with any other plan/policy. Examples: Do the plans/policies cover or impact the same area? How are different organizations contributing to SD planning, STI capacity building or the identification of energy-related opportunities? This analysis should result in a roadmap that describes the specific inter-relationships between all the energy-related planning processes. By having a basis for rationalizing such processes, a package of plans that do not duplicate efforts and are supportive of each other can be created.

- A comprehensive and integrated roadmap is one that is made up of more than all the separate plans/policies put together into one document. It also indicates (1) the time-lines for specific activities in each of those plans/policies, (2) the body that would carry the lead responsibility for the activities, (3) the output from each plan that will be used in other plans, and (4) the key results that are expected to be produced in a specified year in the long term.

It is highly desirable that some of the plans/policies specify the activities or resources devoted to tracking the progress of energy-related technologies. These technologies may be in their basic research stage or at a very early R&D stage. Thus will the government be continuously updated on what is happening on the R&D front and can decide, in a timely fashion, whether it may want to become involved with the technologies as they mature. In the same way, the government may decide to abandon or reduce efforts devoted to areas that are not developing as expected.

Once the Green Technology Council has been provided with the above *information*, the next step is for the Council and the Agency to embark on a joint effort to arrive at a *final roadmap* which defines the path to achieving the Council's overarching objective(s) and goals. (Refer back to the high-level framework of Figure 8.1 in Chapter 8 for a recap on the roles of the Council and the Agency.)

This "Green Technology Roadmap" and the "Roadmap Implementation Action Plan" (see below), would then be distributed to each organization (the third level of the high-level framework, Figure 8.1) that has a planning and implementation role so that every single one of them knows what is to be done in the energy sector with respect to SD, STI capacity building and energy-related opportunities. This simple action will go a long way towards breaking down the 'silo mentality' that currently pervades the country's governmental-planning structure.

Finally, it will be necessary to establish guidelines on how plans should be developed in each cycle of planning. These guidelines should include the following.

- Those organizations currently planning for particular areas should continue to prepare their initial plans or policies.

- For those areas of overlap or duplication, decisions will have to be made by the *Agency* on (1) the organization which is to have *the lead responsibility*, and (2) which other organizations should play *a supporting role*.

- Each planning cycle must be coordinated with the relevant budget cycle. (For example, if the implementation of a plan is to begin in 2012, the planning process must be concluded and the plan submitted to the government in time for the preparation of Budget 2012 which will be announced in October 2011.)

- Planning parameters that will be common to all plans must be explicitly defined by the Agency.

Thus, this Document of Guidelines which details planning rules should be prepared by the Green Technology Agency and circulated to all organizations. This will enable constructive discussions to take place and will promote better planning with minimum bureaucratic cost.

# THE DEVELOPMENT OF AN ACTION PLAN

The reader is reminded that as was the case with a roadmap, the study team has not attempted to formulate an action plan. What follows, hence, is an extensive list of suggestions that are illustrative of *the process of developing an action plan.*

After the development of a roadmap, an action plan is needed to prioritize the areas which will move Malaysia along the path laid out in the roadmap. The study team believes that it should be the responsibility of the Green Technology Agency to prepare the initial draft of this action plan for submission to the Green Technology Council for review and deliberation. After the Agency and Council have decided on the content for the action plan, the Agency should then prepare the final version of that plan. This "Roadmap Implementation Action Plan" will then be provided to all planning organizations so that they would have the necessary guidance to modify their initial/existing plans accordingly. With this, the organizations can then focus on a prioritized list of areas which the Council has decided are the most important for the current planning cycle. This list would cover SD, STI capacity building and various energy-related opportunities.

Important information that should be included in the action plan are:

- A prioritized list, by type and size, of energy-related STI opportunities for adoption in the Malaysian business arena in the period 2010-2020 and the period beyond 2020. Priority must be based on 'best fit' with current and near-term enhancement of the STI resource base. Opportunities to be prioritized must also generate the greatest contribution to sustainable growth.

- An inventory of new energy sources and technologies as well as new ways in which energy can be produced and consumed in the period 2010-2020 and the period beyond 2020.

- Opportunities to reduce energy wastage by changing the energy-waste culture in the country.

- Opportunities which can present a dramatic change in the production and consumption of energy.

- STI resources currently available or needed to take advantage of the opportunities.

- An appropriate way to monitor progress in the pursuance of energy-related opportunities.

- Recommendations for enhancing current governmental actions regarding the expansion of the STI resource base and the monitoring of this expansion.

- Opportunities to develop relationships with other parties in the pursuance of energy-related opportunities beyond 10 years.

- Key elements that must be present in the SD-planning process to ensure the production of effective plans.

- A description of the process entailed by *ex-ante* and *ex-post* evaluations used to assess *expected* and *actual* results of plans.

In short, the action plan must be focused on identifying resources in terms of need and allocation.

### Illustration: *Elements* with Respect to Sustainable Development Planning

The action plan must incorporate the following broad considerations which summarize the "Enabling Conditions" dealt with in Chapter 8.

- Specific actions to remove or reduce economic and non-economic barriers.
- Specific actions ensuring the adoption and enforcement of energy-production and energy-use standards.
- Dedicated resources to track debates about various energy options such that no energy-related alternatives are foreclosed.
- Specific actions of assigning responsibilities to various parties, establishing relationships and ensuring coordination between parties, and establishing a monitoring mechanism.
- Requirements for a coordinated funding mechanism.
- Processes for forecasting expected results (ex-ante) and for tracking actual results (ex-post). (See the section titled "Japan" in Chapter 7.)

### Illustration: *Elements* with Respect to Ensuring the Success of SD Planning

The action plan must incorporate the following elements for *governmental action.* (See the section titled "The United States of America" in Chapter 7.)

- A federal leadership body
- Coordination of RD3E activities across the country
- Adoption of SD principles throughout the government
- Federal investment in sustainable energy R&D
- Stable policies for RD3E and commercialization
- Encouragement of investment in research for commercialization
- Science and technology education
- Workforce training
- Global cooperation
- Reduction of barriers to cross-national collaboration
- Information for consumers and public motivation

The action plan must also have the following elements. (See the section titled "Norway" in Chapter 7.)

- Specific objectives and responsibilities
- A priority list of sustainability issues
- Targets (for the issues) and time frames to achieve them
- Linkage to the National Budget
- Incorporated into the government's everyday business
- Directives for ministries to incorporate the overall SD plan
- Directives for ministries to report regularly
- A set of SD principles
- Policy instruments (to ensure that the principles are adhered to)

### Illustration: *Elements* with Respect to Ensuring the Success of STI Enhancement

The action plan must also factor in the major shortcomings that have plagued and shackled Malaysian STI expansion over the years. Deficiencies identified at the beginning of this decade include the following:

- Gaps in STI achievement between Malaysia and other developing and developed countries are widening; and
- A serious lack of indigenous technology-and-innovation capabilities.

These deficiencies pose challenges in the following manner:

- There is a need to raise awareness and understanding that STI can and must make an important contribution to the development of a knowledge-based economy;
- Closing the STI gap will require a critical and comprehensive push on the human-capital front to generate the right quantity and quality of human resources; and
- Expanding STI programmes will require sizable financing. National R&D expenditure as a percentage of GDP will have to be raised substantially.

The action plan must also factor in some other deficiencies that have already been identified. These have been discussed in the previous chapters under the following headers.

### MOSTI STI Strategic and Action Plan (Chapter 5)

- Adoption of STI culture
- STI to be vigorously promoted
- More open discussion on the development of STI resources
- Quotas and "set asides"

- Promote performance-based management culture
- Adopt consistency in developing STI resources
- Promote STI development at the primary-education level
- Increase capability to implement STI initiatives
- Decision-makers should be conversant with STI principles
- Increase remuneration for STI personnel
- Minimise (or better still, remove) government bureaucracy

### The National Higher Education Action Plan (Chapter 5)

- Remedy shortage of technically-trained graduates
- Enhance employability of university graduates
- Vocational training for graduates to enhance employability

### The Knowledge-Based Economy Master Plan (Chapter 5)

- Remedy lack of cultivation and securing of human resources
- Establish institutions to champion, mobilize and drive transition
- Increase incentives, infrastructure and infostructure
- Enhance capacity for acquisition and application of STI principles at all levels
- Encourage contribution from the private sector
- Enhance development of the public sector into a knowledge-based one
- A knowledge and digital divide to be eliminated

The seven points listed above are to remedy the failure to act upon the strategic thrusts of the K-based plan of 2002.

It should thus be abundantly clear that identifying elements to deal with existing shortcomings is a necessary prelude to moving forward.

We now proceed to present a representative list of elements identified from Malaysian governmental experience that can deal with the shortcomings.

### The National Higher Education Action Plan (Chapter 5)

- Granting universities a greater level of autonomy and accountability.
- Establishing the right process for selection of faculty members.
- Establishing a merit-based remuneration system.

- Strengthening the performance-review process for educators.
- Developing R&D facilities in universities for commercialization.
- Increasing funding for STI courses.
- Evaluation of 'apex' universities.

### MOSTI STI Strategic and Action Plan (Chapter 5)

- Develop a "science is fun" programme.
- Develop a "mathematics is fun" programme.
- Modify the education system to promote innovation and creativity.
- Adopt a participator approach to prioritizing research programmes.

### Suggestions from the Study Team

The study team wishes to make some additional suggestions which should be included in the action plan. These are:

- Mandating specific programmes to accelerate development of human capital.
  - Introduce and/or strengthen entrepreneurship courses in the education curriculum;
  - Promote cross-border exchange of STI talent;
  - Increase dialogue amongst industries, ministries and universities to identify current and emerging STI needs;
  - Review incentives to retain the best and brightest STI graduates; and
  - Restructure the public administrative service for upward mobility of STI-qualified personnel.
- Mandating that priority in all energy-related plans be given to utilizing and increasing home-grown R&D, technology acquisition and innovation in:
  - Sector technology roadmap development and funding assistance for R&D projects, technology acquisition and innovation;
  - R&D collaboration programs; and
  - Techno-entrepreneur development.
- Requiring all energy-related plans to document how they will mainstream STI, and nurture and develop a culture of creative and innovative thinking. Some suggested measures follow.
  - Promote STI policy as one of the (primary) drivers of national development and align it with other development policies.
  - Produce 5-year technology-development plans and road-maps.

  - Facilitate the development of hi-tech SMEs.
  - Implement an STI awareness campaign.
- Enhancing and strengthening alliances between the government, universities, industries and research institutes.
  - Provide a framework for a common platform to coordinate all STI development activities.
  - Make *centres of excellence* independent of government procedures.
- Initiating a programme to strengthen research, development and commercialization.
  - Establish a research-management process that deals with both the projects and the development of research personnel.
  - Promote the brain gain programme to attract outside talent to accelerate the development of STI resources.
- Accelerating R&D commercialization.
  - Develop a national coordinating mechanism for innovation.
  - Provide cash incentives to researchers for developing innovations.
  - Provide training on intellectual property (IP) protection.
  - Establish a monitoring process to track and assess innovations.
- Assisting the Education Ministry to develop and implement a quality STI-education programme at the primary and secondary school levels, including the plans for staffing this program with competent teachers.
- Establishing an application-oriented and innovation-oriented funding mechanism that is independent of the government but overseen by an appropriate government agency.

▪ Establishing a policy that all STI capacity-building activities, including tertiary and advanced-degree education, both share knowledge and cooperate in their work (see Chapter 8 “China”).

▪ Ensuring that there is open access by all parties to all scientific data through a dedicated network (see Chapter 8 “China”).

▪ MOSTI to develop and publish an innovation strategy plan which includes implementation and delivery components.

▪ Establishing “single point” responsibility for coordination and development of STI capacity (this should be MOSTI).

▪ Establishing a policy to promote the free movement of ideas, capital and talent.

▪ Facilitating the availability of funding to encourage innovation.

### Illustration: Identification of Energy-Related *Opportunities*

The action plan must produce a prioritized list of energy-related opportunities for adoption in the Malaysian business arena in the period 2010-2020 and the period beyond 2020. Thus, each organization identified in the High-Level Framework will need to review the area it is responsible for in order to identify these opportunities.

The action plan must include two specific steps for such an identification process:

(1) the analysis of information available (e.g. from market surveys, review of current R&D efforts in Malaysia, published sources, etc.); and
(2) the evaluation and short-listing of the opportunities identified.

A more detailed discussion of these two steps has already been covered in the beginning of Chapter 6. The said chapter also includes the criteria for short-listing opportunities together with their respective quantitative or qualitative indicators. All these must be included in the action plan.

It is absolutely essential that the work of identifying and ranking the energy-related opportunities be completed within 12-18 months to provide a "fact basis" for the government to use in deciding where effort and resources should be expended (1) by the government alone, and (2) by the government in cooperation with universities, institutions and private sector companies.

# THE DEVELOPMENT OF A ROLLOUT PROGRAMME

Once the roadmap implementation action plan is developed, a rollout programme is needed to prioritize the areas and *initial* opportunities that will be the *starting point* for moving the country along the path laid out in the roadmap. The study team believes it should be the responsibility of the Green Technology Agency (as the Managing Authority in the High-Level Framework) to prepare the initial draft of this rollout programme for submission to the Green Technology Council (the Supreme Authority in the High-Level Framework) for review and deliberation. The rollout programme would be constructed from the information contained in the plan or policy documents prepared by the various organizations (the ministries, departments, agencies and special units of the government that form the third level of the High-Level Framework).

After the Agency and Council have decided on the content for the rollout programme, the Agency should prepare the final version of the programme. This rollout programme then would be provided to all organizations so that they would have the guidance necessary to modify their initial plans to focus on the prioritized activities. These activities will cover the areas of SD, STI capacity building, and energy-related opportunities which the Council has decided are the most important for this planning cycle.

The important information that should be included in the Rollout Programme is detailed below. All of this has been 'retrieved' from the Action Plan detailed earlier.

- A prioritized list, by type and size, of energy-related STI opportunities for adoption in the Malaysian business arena in the period 2010-2020 and the period beyond 2020. Priority must be based on 'best fit' with current and near-term enhancement of the STI resource base. Opportunities to be prioritized must also generate the greatest contribution to sustainable growth.

- STI resources currently available or needed to take advantage of the opportunities.

- An appropriate way to monitor progress in the pursuance of energy-related opportunities.

- Recommendations for enhancing current governmental actions regarding the expansion of the STI resource base and the monitoring of this expansion.

- Key elements that must be present in the SD-planning process to ensure the production of effective plans.

- A description of the process entailed by *ex-ante* and *ex-post* evaluations used to assess *expected* and *actual* results of plans.

# FOUNDATIONAL ACTIONS

Listed below are suggested initial actions to be taken with respect to the dimensions of SD planning and STI resource-base enhancement. The study team believes that these actions are foundational and would have a profound effect on all other later (time-lined) actions relevant to the dimensions being treated here. As was done earlier with *information*, the following list of *actions* includes some that have been 'retrieved' from the Action Plan.

## Initial Actions with Respect to SD Planning

- Assign specific responsibilities and accountabilities to government ministries and agencies.
- Establish the R&D relationships between universities, research institutes and the private sector.
- Allocate lead responsibility for the development of specific sectors of the energy industry.
- Ensure coordination of the current infrastructure and human-resource base to focus on the selected opportunities.
- Identify where additional or new resources will be needed and motivate the programmes needed to produce the resources.
- Ensure that the programmes put in place to develop the opportunities are monitored so that the opportunities are realized.
- Ensure that there is a mechanism to continually monitor the energy sector to identify new opportunities and opportunities that are no longer attractive.
- Mandate that each ministry must translate the SD plan into its own annual or 5-year ministerial plan and regularly report on the progress of the plan.
- Identify the actions needed to ensure that the implementation process of the SD plan is integrated into ordinary political activity and the government's budget-development process.
- Define the funding sources, and amounts, that will be dedicated to supporting the implementation of the SD plan.

## Initial Actions with Respect to STI Resource Enhancement

- Mandating specific programmes to accelerate development of human capital.
  - Introduce and/or strengthen entrepreneurship courses in the education curriculum;

  - Promote cross-border exchange of STI talent;
  - Increase dialogue amongst industries, ministries and universities to identify current and emerging STI needs;
  - Review incentives to retain the best and brightest STI graduates; and
  - Restructure the public administrative service for upward mobility of STI-qualified personnel.

- Mandating that priority in all energy-related plans be given to utilizing and increasing home-grown R&D, technology acquisition and innovation in:
  - Sector technology roadmap development and funding assistance for R&D projects, technology acquisition and innovation;
  - R&D collaboration programs; and
  - Techno-entrepreneur development.

- Requiring all energy-related plans to document how they will mainstream STI, and nurture and develop a culture of creative and innovative thinking. Some suggested measures follow.
  - Promote STI policy as one of the (primary) drivers of national development and align it with other development policies.
  - Produce 5-year technology-development plans and road-maps.
  - Facilitate the development of hi-tech SMEs.
  - Implement an STI awareness campaign.

- Enhancing and strengthening alliances between the government, universities, industries and research institutes.
  - Provide a framework for a common platform to coordinate all STI development activities.
  - Make *centres of excellence* independent of government procedures.

- Assisting the Education Ministry to develop and implement a quality STI-education programme at the primary and secondary school levels, including the plans for staffing this program with competent teachers.

- Establishing an application-oriented and innovation-oriented funding mechanism that is independent of the government but overseen by an appropriate government agency.

# TIME-LINED ACTIONS

Based on the work done by experts and using the criteria discussed earlier, the study team has identified the following energy-related opportunities as 'candidates' to be considered for *early action* by the relevant government organizations.

## The Energy Consumption/Utilization Sector

### Enforcing Minimum Energy Standards and Retrofitting Existing Buildings

- Set minimum energy standards for all buildings, then enforce these using the Green Building Index (GBI) since it is already in place for both residential and non-residential buildings.
- Retrofit existing buildings that are reaching their 30-year mark in terms of age in accordance with the same minimum-energy standards.
- Implement and enforce the Malaysian Standard on Energy Efficiency (MS 1525). Its full enforcement has been mysteriously delayed for too long. This must be done for buildings with GFA < 4,000 square metres within 5 years and extended to all buildings within 10 years.
- Coordinate all construction activity in the country towards the eventual realization of zero-energy buildings.
- Raise the EE benchmark of air-conditioning equipment that is used extensively in the country e.g. direct-expansion unitary compressors. This must be done within 5 years.
- Move the country towards becoming an industry leader by setting up R&D test laboratories for direct-expansion unitary air-conditioning equipment. Set a 10-year target for this.
- Use the R&D test laboratories referred to earlier to also seek design improvements in VAC (ventilation and air-conditioning) equipment. Emphasize areas such as displacement ventilation, active/passive chilled beams/slabs. Set a 10-year target for capacity building and tangible results.
- Promote and accelerate local development and production of 'quality' EE lighting e.g. T5 lamps, VFDs, LEDs, etc. Set a 5-year target for successful local production and 10 years for maturity.

### Replacing Synthetic Refrigerants with Hydrocarbon Refrigerants

- Negotiate a deal with PETRONAS for the supply of natural gas to be used as a raw material for the production of hydrocarbon refrigerants. This must be done immediately.
- Set up a GLC to produce hydrocarbon refrigerants using natural gas supplied by PETRONAS. This must be done immediately.
- Enforce the use of hydrocarbon refrigerants in all air-conditioning and refrigeration equipment nationwide. This must be done within the $10^{th}$ Malaysia Plan.
- Replace existing refrigerants with hydrocarbon refrigerants in all existing air-conditioning and refrigeration equipment nationwide. This must be done within the $10^{th}$ Malaysia Plan.

### Transportation Improvements

- Establish and enforce fuel consumption standards for all new vehicles within the $10^{th}$ Malaysia Plan.
- Commission a study to determine if a proposal to rely entirely on diesel engines in all future road vehicles is worth considering. This must be completed within the $10^{th}$ Malaysia Plan.
- If the study returns a favourable result for the proposal to shift entirely to diesel engines, require all new vehicles in Malaysia to be diesel-fuelled. The time-frame for this must be set by MOT (the Ministry of Transport).
- Establish a transportation "centre of excellence" (see details below).

Most of the transport-related opportunities that were detailed in Chapter 6 and translated into recommendations in Chapter 8 are not likely to be realized before 2020. This is due in no small way to the existing infrastructure that renders any move to bring improvements a painfully slow process. However, it will be essential for the government to establish a transportation "centre of excellence" that can focus for the next 10 years on the key issues facing the transportation sector. In this way, the country will have a well-defined set of opportunities ready for action towards the end of the current decade.

## The Power-Generation Sector

### Coal Utilization for Power Generation

Consolidate any/all research currently underway in the country regarding "clean power generation using coal". Aim for tangible results within 3-5 years that would allow the government to have a "fact base" to decide whether to pursue the option of using coal for power generation. Technical approaches currently under investigation worldwide include:

- Carbon capture and sequestration (CCS)
- Integrated gasification combined cycle (IGCC)
- Coal-to-liquids potential
- Underground coal-gasification potential
- Enhanced fluidized-bed-combustion technology

➢ Set up a facility to explore the emerging technology in which carbon dioxide can be recycled into a fuel substance.

➢ Set up a facility to exploit the facility (which has reached commercial stage) in which salt water is sprayed on flue gases to convert carbon dioxide into calcium carbonate which can be used as a construction aggregate.

➢ Examine the scientific basis that algae-conversion technology applied to a coal-fired power-generation plant can remove 5,000 tonnes of emitted carbon dioxide daily and produce 750,000 gallons of petrol.

## Developing PV Potential into a Major Industry

The study team believes that Malaysia has the potential to be a world player in the PV industry. The set of actions proposed here can be completed within an estimated time-frame of 10 years.

➢ Establish a National PV Industry Development Programme. This should be done within 1 year. (The background to this action can be found in Chapter 8 – Recommendations from the Study Team.)

➢ Establish a new technology sector based on PV-derived electricity. This sector has a high growth potential possibly providing 100,000 jobs by 2020.

➢ Allocate an estimated RM250 billion to be utilized between 2010 and 2020 to facilitate the country capturing a 10% share of the global PV market. Most of this money would be invested locally.

➢ Guarantee access to the National Grid for every solar-PV energy producer with a legally guaranteed feed-in tariff for a period of 20 years to protect each producer’s investment.

➢ Launch a defined strategy for phasing out fossil fuels by mobilizing solar-PV energy to the maximum. (The country must bear in mind that the prevailing wisdom on this matter is that it cannot be done.)

➢ Enter into an international emissions-trading system which should create financial incentives to develop solar-PV energy.

➢ Promote a renewable-energy priority for financing renewables, particularly solar-PV energy, in development aid and development banks, focusing on microfinance. (Adopt the model used by the Grameen Shakti Bank.)

- Promote the adoption of global industrial norms and standards for renewables, particularly solar-PV energy.

## Other Opportunities Related to Renewable Energy

### *Establishment of a Special-Purpose GLC*

- Establish a special-purpose GLC as a wholly-owned subsidiary of PETRONAS to be responsible for researching and developing a defined package of alternative energy sources.

The justification for this action and full details of the specific areas to be covered are in the section titled "Renewable Energy" in Chapter 8 – Recommendations from the Study Team.

### *General Initial Actions Related to Renewable Energy*

- Establish a dedicated national renewable energy agency as a governmental organization (possibly with voluntary membership).
- Develop financing and technology-transfer mechanisms related to renewable energy.
- Establish an international university for renewable energy with focus on intensive research and postgraduate qualifications.

## The Oil and Gas Sector

- Stop the brain drain to West Asia on the part of PETRONAS staff by restructuring the company's remuneration system.
- Rejuvenate mature oil fields using EOR techniques to realize a further 5-10% increase in the recovery factor.
- Develop small and marginal oil fields.
- Intensify exploration to find new oil fields in deeper and frontier areas.
- Develop small and marginal natural gas fields.
- Re-evaluate exploration data pertaining to gas reservoirs.

Background details to all of the above actions have been adequately provided in Chapter 6 – STI: R&D, Applications and New Opportunities.

# CHAPTER TEN — References And Appendices


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**(The Appendices mentioned in this Report are available with the Academy of Sciences Malaysia for reference)**