

A ROADMAP OF EMISSIONS INTENSITY REDUCTION IN **MALAYSIA**



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Glossary

ACEM	Association of Consulting Engineers Malaysia
AIDS	Acquired Immune Deficiency Syndrome
AMB	Ambitious
APFSOS	Asia Pacific Forestry Sector Outlook Study
ATC	Agriculture Tree Crop
ATF	Aviation Transport Fuel
AWD	Alternate Wetting and Drying
AWMS	Animal Waste Management System
BAU	Business-As-Usual
BCM	Billion Cubic Metre
BEST	Bio-ethanol for Sustainable Transport
BF	Blast Furnace
BFBC	Bubbling Fluidised Bed Combustion
BOD	Biochemical Oxygen Demand
BOF	Blast Oxygen Furnace
BPKM	Billion Passenger Kilometre
BREEAM	Building Research Establishment Environmental Assessment
BTKM	Billion Tonne Kilometre
CAFÉ	Corporate Average Fuel Economy
CAGR	Compound Annual Growth Rate
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
CBO	Community Based Organization
CBR	Crude Birth Rate
CBU	Completely Built Up
CCRD	Centre for Rural Communities Research & Development
CCS	Carbon Capture and Storage
CCT	Clean Coal Technology
CDM	Clean Development Mechanism
CDR	Crude Death Rate
CEC	Cation Exchange Capacity
CER	Certified Emission Reduction
CETDEM	Centre for Environment, Technology & Development, Malaysia
CFBC	Circulating Fluidised Bed Combustion
CFC	Chlorofluorocarbon
CFL	Compact Fluorescent Light
CGC	Credit Guarantee Corporation Malaysia Berhad
CHP	Combined Heat Power
CNG	Compressed Natural Gas
COD	Chemical Oxygen Demand
COP	Conference of Party
CRIF	Commercial Regeneration Improvement Felling
CTI	Climate Technology Initiative
DBH	Diameter at Breast Height
DBKL	Dewan Bandaraya Kuala Lumpur
DNDC	DeNitrification-DeComposition

DOC	Degradable Organic Carbon
DRI	Direct Reduced Iron
DRIF	Departmental Regeneration Improvement Felling
E&E	Electrical & Electronics
EAF	Electric Arc Furnace
EAI	Energy Alternatives India
EE	Energy Efficiency
EPC	Energy Performance Contracting
EPU	Economic Planning Unit
ESCOs	Energy Service Companies
ESP	Electrostatic Precipitators
EST	Environmentally Sound Technology
ETP	Economic Transformation Programme
ETS	Electric Train Service
EU	European Union
FBC	Fluidized Bed Combustion
FDs	Forest Departments
FGD	Flue Gas Desulphurization
FLEGT	Forest Law Enforcement, Governance and Trade
FMU	Forest Management Unit
FP	Forest Plantations
GBI	Green Building Index
GDP	Gross Domestic Product
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIF	Green Investment Fund
GNI	Gross National Income
GPNM	Global Partnership on Nutrient Management
GPP	Gross Primary Production
GTFS	Green Technology Financing Scheme
GTP	Government Transformation Programme
HDI	Human Development Index
HIV	Human Immunodeficiency Virus
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IEPR	Institute of Energy Policy and Research, UNITEN
IGCC	Integrated Gasification combined cycle
IMP	Industrial Master Plan
IPCC	Intergovernmental Panel on Climate Change
IPPs	Independent Power Producers
IPR	Intellectual Property Right
IRRI	International Rice Research Institute
IST	Individual Septic Tank
ITA	Investment Tax Allowance

ITTO	International Tropical Timber Organization
IWK	Indah Water Konsortium
JICA	Japanese International Corporation Agency
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
KLIA	Kuala Lumpur International Airport
KPKT	Ministry of Housing and Local Government
KTMB	Keretapi Tanah Melayu Berhad
LA	Local Authority
LCCF	Low Carbon Cities Framework
LED	Light Emitting Diode
LEED	Leadership in Energy and Environmental Design
LESTARI	Institute of Environment and Development, UKM
LFG	Landfill Gas
LFPR	Labour Force Participation Rates
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LPPKN	Lembaga Penduduk dan Pembangunan Keluarga Negara
LRT	Light Rail Transit
LULUCF	Land Use, Land Use Change and Forestry
MAC	Marginal Abatement Cost
MARDI	Malaysian Agricultural Research and Development Institute
MARKAL	Market Allocation Model
MBIPV	Malaysian Building Integrated Photovoltaic
MC & I	Malaysian Criteria and Indicators
MDG	Millennium Development Goals
MEGTW	Ministry of Energy Green Technology and Water (KeTTHA)
MENGO	Malaysia Environmental NGO
MEPS	Minimum Energy Performance Standards
MGTC	Malaysia Green Technology Corporation
MHLG	Ministry of Housing and Local Government
MIEEIP	Malaysian Industrial Energy Efficiency Improvement Project
MMD	Malaysian Meteorological Department
MoT	Ministry of Transport
MP	Malaysia Plan
MREPC	Malaysian Rubber Export Promotion Council
MRF	Material Recovery Facilities
MSW	Municipal Solid Waste
MTCC	Malaysian Timber Certification Council
NAP	National Agricultural Policy
NBP	Net Biome Production
NC	Initial National Communication
NC2	Second National Communication
NDP	National Development Programme
NEB	National Energy Balance
NEP	Net Ecosystem Production
NFA	National Forestry Act
NFC	National Forestry Council
NFP	National Forestry Policy

NG	Natural Gas
NGV	Natural Gas Vehicle
NLC	National Land Council
NMVOC	Non-methane Volatile Organic Compounds
NPP	Net Primary Production
NRE	Ministry of Natural Resource and Environment (MNRE)
NREPAP	National Renewable Energy Policy and Action Plan
NSP	National Strategic Plan
NSWMD	National Solid Waste Management Department
NTFP	Non Timber Forest Produce
OIIP	Oil Initially in Place
PAM	Pertubuhan Akitek Malaysia
PC	Pulverised Combustion
PDA	Petroleum Development Act
PEFC	Programme for the Endorsement of Forest Certification
PFE	Permanent Forest Estate
PIA	Promotion of Investment Act
PINE	Public Information Nuclear Energy
POME	Palm Oil Mill Effluent
POIC	Palm Oil Industrial Cluster
PPA	Power Purchase Agreement
PPC	Portland Pozzalona Cement
PRF	Permanent Reserved Forests
PS	Pioneer Status
PSC	Production Sharing Contract
PTM	Pusat Tenaga Malaysia
PV	Photovoltaic
PVC	Pulverized Coal Combustion
QSL	Queneau, Schumann and Lurgi
RD&D	Research, Design and Development
RDF	Refuse Derived Fuel
RE	Renewable Energy
REDD	Reducing Emissions from Deforestation and Forest Degradation
REDD+	Extends REDD by Sustainable Forest Management, Conservation of Forests and Enhancement of carbon sinks
RM	Ringgit Malaysian
SEB	Sarawak Energy Berhad
SEC	Specific Energy Consumption
SESB	Sabah Electricity Sdn Bhd
SEZ	Special Economic Zone
SFM	Sustainable Forest Management
SFMLA	Sustainable Forest Management Licence Agreement
SIRIM	Standard & Industrial Research Institute of Malaysia
SLF	State Land Forest
SMEs	Small and Medium Enterprises
SMR	Standard Malaysian Rubber
SREP	Small Renewable Energy Programme
STP	Sewage Treatment Plants
SWPCM	Solid Wastes and Public Cleansing Management

TEDDY	TERI Energy Data Directory
TERI	The Energy and Resources Institute
TFL	Tube Fluorescent Light
TNA	Technology Need Assessment
TNB	Tenaga Nasional Berhad
TPA	Totally Protected Areas
TPD	Tonnes Per Day
UKM	Universiti Kebangsaan Malaysia
UNDP	United Nation Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nation Framework Convention on Climate Change
UNITEN	Universiti Tenaga Nasional
UPM	Universiti Putra Malaysia
USD	United states Dollar
USEPA	United States Environmental Protection Agency
VACVINA	Vietnam Gardening Association
WMAM	Waste Management Association of Malaysia
WM-M/P	Master Plan on National Waste Minimisation

Foreword

I am pleased to present the study “A Roadmap of Emissions Intensity Reduction in Malaysia”. This study undertakes a comprehensive analysis directed at mitigation prospects, potential and strategies across various sectors and uses an integrated analytical framework to delineate a mitigation roadmap for Malaysia. A bottom-up approach was adopted to assess changes in end-use demands and activity levels across sectors, evaluate specific technologies and options across sectors, and develop scenarios for energy and non-energy Greenhouse gas (GHG) emitting sectors to assess the potential for GHG emission reduction.



At the 15th Conference of Parties of the United Nations Framework Convention on Climate Change (UNFCCC) in 2009, the Honourable Prime Minister announced that Malaysia was adopting a voluntary indicator to reduce emissions intensity of Gross Domestic Product (GDP) by up to 40% by 2020 as compared to 2005 levels, subject to availability of technology and finance. In this regard, the Ministry has taken the initiative to develop a roadmap to address the GHG emissions reduction and identify opportunities for GHG emissions abatement towards achieving up to 40% reduction in carbon emission intensity.

This report lays out the roadmap of the key sectors in Malaysia such as Energy, Industrial Processes, Agriculture, Waste and Land Use and Land Use Change (LULUCF) sectors, for short, medium and long term mitigation options to reduce the GHG emissions. The report also includes the technology needs assessment and low carbon economy approaches to climate change mitigation.

I note with pleasure here that the report indicates that Malaysia has ample opportunities across various sectors to actually meet its voluntary reduction of 40% emissions intensity of GDP. However, while these opportunities exist, some sectors require adequate finance, availability of appropriate technologies or enabling policies and institutional environments to realise the potential savings. The report then provides prioritised options that the country should undertake in order to move towards a low carbon pathway, and suggests specific policy interventions to guide the development along this sustainable development path.

I hope this report will be an effective roadmap to guide ministries and government agencies to achieve the intended emission reductions in the country.

I would also like to thank all who have contributed in making this study a success.

Thank you.

A stylized, handwritten signature in black ink, consisting of a series of loops and a long horizontal stroke.

DATO' SRI ZOAL AZHA YUSOF

Secretary-General Ministry of Natural Resources and Environment

EXECUTIVE SUMMARY

Introduction

At COP 15, the Honourable Prime Minister of Malaysia made a voluntary pledge of up to 40% reduction of Greenhouse Gas (GHG) emissions intensity of GDP by 2020 as compared to 2005 levels, subject to availability of technology and finance. Following this, The Ministry of Natural Resources and Environment (NRE) awarded a study “A Roadmap of Emissions Intensity Reduction in Malaysia” to Universiti Tenaga Nasional (UNITEN). The Energy and Resources Institute (TERI) in collaboration with UNITEN led the mitigation component of this study and provided overall advice in terms of delineating the roadmap for Malaysia. This study undertakes a comprehensive analysis directed at mitigation prospects, potential and strategies across various sectors and uses an integrated analytical framework to delineate a mitigation roadmap for Malaysia. A bottom-up approach was adopted to assess changes in end-use demands and activity levels across sectors, evaluate specific technologies and options across sectors, and develop scenarios for energy and non-energy GHG emitting sectors to assess the potential for GHG emission reduction. A review of existing and planned policies and measures has also been undertaken to enable a better appreciation of the success of existing measures and to thereby evaluate the feasible potential for emission reduction in each of the key sectors. Business-as-usual (BAU) and Ambitious (AMB) scenarios have been developed in each of the sectors to examine the emission reduction possibilities and to eventually delineate a mitigation roadmap for the Malaysian economy. For the energy sector in particular, the MARKAL model has been used to undertake an integrated analysis of energy demand and supply in order to examine the effects of energy savings and fuel substitution possibilities on emission reduction potential across the energy sector as a whole.

This final report presents a detailed analysis of mitigation options and potential in each of the sectors till 2030 and evaluates the feasibility of achieving the voluntary 40% emissions intensity of GDP reduction target through an integrated framework. It also lays out a roadmap for each of the key sectors in terms of suggestions for the short, medium and long term, based on the analysis. The report also includes the technology needs assessment and low carbon economy approaches to climate change mitigation.

Mitigation Analysis

The study indicates that Malaysia has ample opportunities across various sectors to actually meet its voluntary reduction of 40% emissions intensity of GDP. However, while these opportunities exist, large efforts would be required in some sectors to actually realise the potential savings in terms of adequate finance, availability of appropriate technologies, the right skill sets or enabling policies and institutional environments.

Business-as-Usual Scenario (BAU)

An integrated analysis across all the sectors indicate that GHG emissions without considering the LULUCF sector, under the BAU scenario, would increase from around 253.9 MtCO₂ eq. in 2005 to 390.08 MtCO₂ eq. in 2020 and 570.64 MtCO₂ eq. in 2030. This translates to an emissions intensity reduction by 28% in 2020 and by 31% in 2030 from 2005 levels without considering LULUCF in the BAU scenario. It is, therefore apparent that with current efforts and existing plans and policies as reflected in the BAU scenario, Malaysia would achieve a significant reduction in carbon emission intensity but would fall short of its commitment of 40% emission intensity reduction by 2020.

When reduction in emissions intensity is considered with LULUCF, in the BAU scenario, emission intensity decrease as compared to 2005 levels by 111% in 2020 and then increases by 50% in 2030, since Malaysia was a net sink in the past and has gradually become a net emitter.

Ambitious scenario (AMB)

In an Ambitious scenario (AMB), the emissions without considering LULUCF as compared to BAU scenario (390.08 MtCO₂ eq. in 2020 and 570.64 MtCO₂ eq. in 2030) would reduce to 302.45 MtCO₂ eq. and 385.89 MtCO₂ eq. in 2020 and 2030 respectively. As a result, emission intensity reduces by 44% in 2020 and by 53% in 2030 from 2005 levels. With additional efforts directed towards mitigation as suggested in the AMB scenario, Malaysia could therefore meet its commitment of 40% reduction in emissions intensity by 2020 even without considering LULUCF.

When LULUCF is considered, in the AMB scenario, the emissions intensity decreases from 2005 levels by as much as 225% in 2020 and 101% in 2030 respectively.

The analysis clearly indicates that if efforts were made across all sectors in line with those considered in the AMB scenario, the voluntary 40% emissions intensity reduction is achievable by 2020 itself and beyond.

From the viewpoint of negotiations and the country's response to the Copenhagen accord, it is important for Malaysia to consider how it would like to interpret the voluntary reduction in terms of considering the inclusion of the LULUCF sector, both at the base year level and beyond. In this study, we conduct the analysis for both cases (without and with LULUCF sector), but also flag this as an important consideration for the Government to further deliberate upon.

A sensitivity analysis for GDP growth rate also indicates that it is important for Malaysia to maintain a high growth rate of GDP (at 6% per annum at least) over the next decade and beyond. If the economy were to grow at a GDP growth rate of 4.2% per annum, (indicative of the economic growth patterns envisaged in the Economic Transformation Programme of Malaysia), it is observed that the voluntary target of 40% emission intensity reduction would not be achieved by 2020 even with emission reductions as envisaged in the Ambitious scenario in the without LULUCF case. However, it is achieved in the with LULUCF case. The focus on high GDP growth is important also for moving towards the target of increasing Malaysia's per capita income to around USD 15,000 (RM 48,000) by 2020. It would be beneficial for Malaysia to focus on encouraging growth in activities and sectors that can provide high value addition to the economy without entailing a high level of emissions.

The key sectors where Malaysia needs to direct its attention are the waste management, the power and transport sectors. These sectors are not only relevant in terms of the level of emissions that can be attributed to them if adequate attention is not paid, but also in terms of how much they can contribute to mitigation and achievement of the 40% emission intensity reduction target by 2020.

Mitigation Roadmap

The study reveals that some sectors offer relatively small potential for emission reduction, while others can bring in huge benefits. The level of efforts and allocation of funds should, therefore, be judiciously allocated to the key areas that can help Malaysia realize its mitigation target.

Prioritization of mitigation efforts also needs to be evaluated in terms of their timeliness. There exist several "win-win" opportunities or "low hanging fruits" especially on the energy demand side wherein simple measures could be adopted to increase awareness, set up standards and undertake audits etc. in order to provide a facilitative environment for energy efficiency improvement across the sectors. Such measures can be adopted quickly in the immediate short term to reap their benefits till such time that the alternative options that benefit the medium to long term can be deployed.

Solutions that involve changing supply side technologies or using alternative fuels involve a significant gestation period and a switch towards such options should necessarily be preceded by adequate due diligence, investment of time and resources in R&D and skill enhancement and in setting up of appropriate supportive policy and regulatory changes.

Accordingly, the roadmap for 40% emissions intensity reduction in Malaysia needs to consider the various recommendations in a phased manner (short /medium /long term) and with varying levels of prioritization and urgency as delineated in this report.

Some of the main highlights of the mitigation roadmap are provided below:

LULUCF Sector

The LULUCF sector is clearly the most important sector for Malaysia, not only by virtue of forestry and allied activities playing an important role from various development and economic perspectives such as employment generation, trade and protection of ecosystems, but also from the mitigation point of view. Forests are a net sink of carbon in Malaysia and contribute towards providing ecosystem services including carbon sequestration in addition to direct use value to the society in the form of timber and non-timber forest products.

It is estimated that the forestry sector along with agriculture tree crops has the potential to sequester around 409 MtCO₂ eq. in 2030 without affecting ecosystem services and biodiversity conservation. Malaysia therefore must make every effort to strengthen research and capacity building in respect to sustainable forest management to optimize the environmental benefits from forests. Malaysia needs to have strong and well-defined systems and institutions at the national level to regulate diversion of forests for non-forestry use and to be able to maintain its commitment of having minimum 50% forests.

There is also a need to enhance investment in the forestry sector which is inadequate at present to optimize the environmental benefits from forests. Malaysia needs to shift focus to timber harvest largely from forest plantations, rather than depending largely on Production Permanent Reserve forest. The export of only value added products of wood could help bridge the gap in revenue, due to conservation oriented approach. In addition, Malaysia should take a proactive approach during international negotiations, particularly in climate change negotiations to maximize the advantage of REDD+.

Waste Sector

In the waste sector, it is observed that an AMB scenario can lead to a reduction in emissions of about 69% by 2020 and 2030. The waste sector holds considerable importance as well, since waste generation is likely to increase rapidly and control of resultant emissions in the future needs to be addressed. Technologies and options for mitigation do not pose too much of a challenge, but significant efforts are envisaged in terms of investment requirements and infrastructural and institutional support to bring about implementation of the requisite measures in this sector.

Energy Sector

In the energy sector, it is observed that an AMB scenario can lead to a reduction in emissions of about 17.0% by 2020 and 29.7% by 2030. There exist several “win-win” opportunities or “low hanging fruits” for the energy sector especially on the energy demand side wherein simple measures could be easily adopted that brings and start bringing in mitigation benefits quickly. For example, in the residential sector, schemes promoting use of efficient appliances coupled with awareness programmes on energy saving methods; energy audits in industries not only monitor the energy use patterns but also provide information on ways to save energy (and improve the competitiveness of units) plays an important role in the immediate short term. The Government in particular needs to play an important role not only in establishing policies and schemes that encourage efficient energy use and penalize wastage schemes, but also in providing conducive regulatory mechanisms. Such measures can be adopted quickly in the immediate short term to reap their benefits.

While there are several opportunities for improving energy efficiency, especially across the end-use energy demand sectors, given that the Malaysian economy plans for rapid development and increase in per capita income, it is possible that the benefits of savings from efficiency would get negated to an extent by increasing energy consumption over time. Accordingly, planners and policy makers would need to not only holistically evaluate the most suitable set of technological options and infrastructure development considerations for the economy, but also simultaneously put in place appropriate fiscal and regulatory measures that would promote sustainable consumption patterns in the economy.

Apart from this, within the energy sector, the transport and power sectors are the main areas to focus on. Emphasis on reducing reliance on personalised modes of transportation, encouraging the move towards efficiency improvement and use of cleaner fuels in vehicles are some of the important options for Malaysia in the transport sector as detailed in the report. In case of power generation, while a shift to cleaner fuel options such as renewable energy should be considered in the long run, moving towards more efficient generation options is important. Given the large gestation period associated with power generation infrastructure, it is also important for Malaysia to re-consider the relative importance of coal based generation in its capacity mix in the short term.

Technology needs and development

With regard to the technology development, the power and transport sectors need to make deliberated efforts in the medium term to bring in technologies that are most suited to the Malaysian context for the long term. The power sector should focus on R&D and technology change as power demands would continue to increase rapidly, and changes to super-critical rather than sub-critical coal based technologies in the power sector can be brought in even in the short and medium term, while the share of zero carbon options would need to be increased in the longer term. In the transport sector as well, given the need to decrease dependence on petroleum fuels, technology development to enhance the use of electricity based on renewable energy and other alternative fuels are suggested. Several options for efficiency improvement exist even in short term in the residential, commercial and industrial sectors and can be easily provided in the short to medium term. On the other hand, suitable technology options in the waste sector are also well known and should be brought in by the medium to long term.

Finance and investment needs

With regard to finance and investment needs, within the energy sector, the power and transport sectors need the largest focus in the medium to long term for additional investment especially if alternative fuel and technology options such as nuclear and renewable energy are adopted.

In the case of the transport sector, it is important to note that both public transport and increase in rail based movement would entail significant investments to be incurred on the part of the government (public spending) rather than personal expenditure on the part of consumers as in case of personalised transportation modes.

Investment needs are also expected to be high in the waste sector and need to be carefully planned in the short to medium term. In case of LULUCF, while some immediate short term measures can be undertaken without much investment, in the long term, the sector is the most important for Malaysia's mitigation target. Therefore, there is a need to enhance resources for the implementation of sustainable forest management in Malaysia including forest development, capacity building of human resources, and research and development.

R&D and Institution Interventions

In terms of institutions and policy changes, Malaysia already has several policies in the right direction which need to be strengthened and have their adoption and implementation facilitated. The transport sector in particular, has a large need for focusing on the policy and institutional side as is the case with other demand side sectors such as the residential and commercial sectors.

In the transport sector, while R&D is not seen as an immediate and high priority area, there is a large opportunity to bring about technology change (modal shifts) in the medium to long term. High priority needs to be accorded to directing investment towards enhancing public transport and introducing legislation frameworks that facilitate greater fuel efficiency.

In the industrial sector, several technologies are available for enabling emission reductions in an easy and cost-effective manner. While research and development is essential in the long run, a little effort with respect to investment and technology development will go a long way in improving the performance of the industrial sector. It will be essential for the institutional set-up to be strengthened such that the sector is at par with global standards.

The residential and commercial sectors provide adequate potential for emissions reduction and should be considered a priority sector. R&D activities linked to this sector need to focus on the use of renewable energy, particularly solar, that could be taken up even in the short term. Most technology changes in these sectors would not require large investments and it should be considerably easy to improve the overall energy use intensity in this sector. Institutions however need to play an important role in ensuring that the right kind of policy environment is created to enable the technology changes.

In the agriculture sector, research and development activities along with technology development are important in the medium and long term to improve practices such as livestock management and manure management. Overall, the sector does not call for a very high priority being accorded to investment, institutional capacity building, etc.

Given that some of the sectors offer relatively small potential for emission reduction, while others can bring in huge benefits, the level of efforts and allocation of funds should, therefore, be judiciously allocated to the key areas that can help Malaysia realize its mitigation target.

Mitigation Potential by Sector

The summary of the emission reduction potential is given in Table E.1 below.

Table E.1: Emission reduction potential by sector (MtCO₂ eq.)

Sector	2005	2020		2030	
		BAU	AMB	BAU	AMB
Energy (Electricity)	57.5	85.6	71.7	136.2	97.4
Transport	45.3	88.7	70.5	125.3	80.5
Industrial	35.5	35.5	31.5	49.2	40.9
Residential & Commercial	4.3	9.2	8.1	18	12.3
Others*	61.8	95.0	78.8	142.5	100.2
Total Energy	204.40	314.00	260.63	471.20	331.30
Industrial processes	15.6	22.3	21.4	33.8	30.2
Agriculture	6.6	7.2	5.8	8.3	6.7
Waste	27.4	46.6	14.7	57.3	17.7
LULUCF net emissions (source – sink)	-215.2	-399.1	-405.7	-381.0	-386.6
Total without LULUCF	253.90	390.08	302.45	570.64	385.89
Total with LULUCF	38.70	-9.06	-103.22	189.68	-0.68
GDP (RM million)	449,250	961,214	961,214	1,463,191	1,463,191
Emission Intensity (kg CO ₂ /RM) without LULUCF	0.565	0.406	0.315	0.390	0.264
Emission Intensity (kg CO ₂ /RM) with LULUCF	0.086	(0.009)	(0.107)	0.130	(0.001)
Reduction in Emission Intensity from 2005 level without LULUCF (%)		28%	44%	31%	53%
Reduction in Emission Intensity from 2005 level with LULUCF (%)		111%	225%	(50%)	101%

*Others include emissions from Energy industries such as fugitive emissions, manufacture of solid fuel, petroleum refining, etc

Development of Technological Interventions towards Low-Carbon Economy Pathways

In developing low carbon economy pathways, within the context of climate change, much emphasis has been given to mitigation strategies including technologies to reduce atmospheric GHG concentrations by reducing emissions and enhancing sinks. However, technologies for adaptation to climate change are equally important towards the health, coastal, food, ecosystem and water sectors. Some of the examples of technological intervention for adaptation include improving the penetration of cooling load, improving flood-defence systems and irrigation, and developing monitoring, forecasting and early warning systems for natural hazards.

Low carbon economy not only becomes a social economic development pathway for Malaysia's future, but also facilitates its economic restructuring and accelerates the growth of industries with low energy consumption and high added value. The government policies thus have a key impact on the demand and development for low carbon economy pathways. Furthermore, government procurement, taxes and subsidies have a direct influence on the price of low carbon alternatives. A broad policy framework for low carbon economy covers three areas namely; carbon pricing, technology policy (to promote development and dissemination of low carbon energy resources and high efficiency end use appliances and buildings), and removal of barriers to behaviour change towards new technologies and using high efficiency end use options).

For Malaysia to achieve low carbon economy pathways there are several potential options that can be categorized into the following four areas:

1. Reducing carbon content of energy resources
2. Energy efficiency and conservation for low carbon growth
3. Facilitating low carbon industries and services development to promote economic growth.
4. Low carbon alternatives for non-energy sectors.

Given the four (4) areas above, Malaysia needs to identify the appropriate technologies for each sector namely power sector, residential and commercial, transport, industrial and industrial processes, waste and agriculture.

The technologies selected for the power sector includes advanced coal technology, clean coal technology, nuclear power, integrated gasification combine cycle plants and using biomass. While for residential and commercial sector, the selected technologies give emphasis on more efficient utilisation of energy and converting to more energy efficient appliances.

The transport sector focuses on the technological and policy intervention on the following areas namely: increasing the share of passenger and freight in rail transportation, increasing share of public transportation, improving the technology and efficiency of vehicles and emission standards and increasing the use of alternative and cleaner fuels. An integrated urban and regional planning for the transportation sector could also be an effective option for reducing GHG emissions.

For the industrial sector, the key intervention is to enhance energy efficiency and utilising raw materials with lower carbon content in the industrial processes.

The technology option for the waste sector focuses on incinerator, anaerobic digestion, and sanitary landfill with gas recovery. The agriculture sector, on the other hand, will focus on research and development for improving crop yield, manure and fertilizer management.

The priorities for the low carbon investment are depicted by the GHG abatement cost curve for each of the sectors as shown in Figure E.1. below.

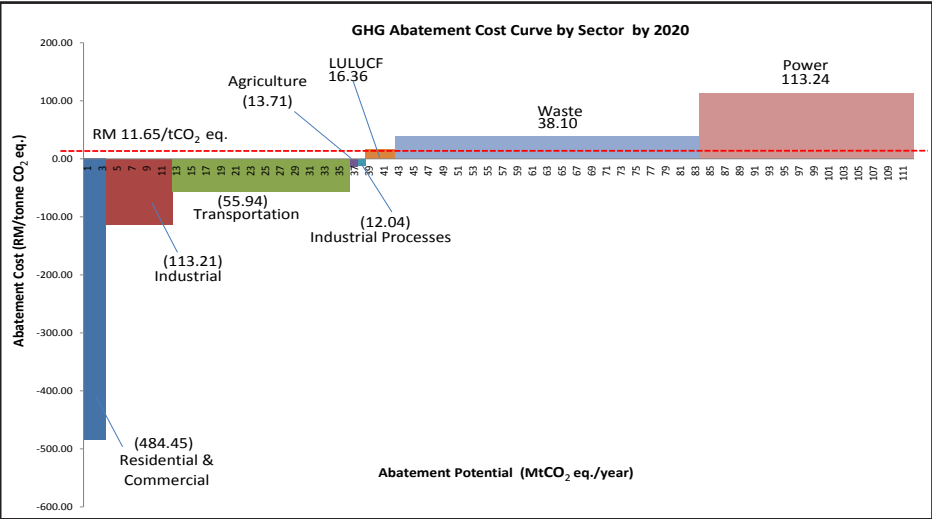


Figure E.1: GHG abatement cost curve by sector 2020

To achieve low-carbon economy pathways, there is a need for an integrated policy for sustainable development based on sustainable low-carbon policies for all key socio-economic sectors (i.e., agriculture, industrial, transport, energy and water resources, etc). This requires better coordination and integration of the sustainable low-carbon policies for all key socio-economic sectors which can be effectively implemented through the National Green Technology and Climate Change Council chaired by the Prime Minister.

Further study is necessary to evaluate the social and environmental impact of all the proposed options using the life cycle assessment methodology. It is necessary to consider the potential social and environmental costs (i.e., the externalities) for each of the proposed options. The exercise would enable a ranking of priority options based on cost-effectiveness and sustainability.

Conclusion

It is commendable that the Malaysian Government has taken on an ambitious voluntarily target for emissions reduction. At the same time, the government has already set in motion several policies and measures for energy and emissions saving. The country needs to holistically evaluate its development path and options that it would like to consider from various perspectives – be they in terms of employment opportunities, larger welfare considerations at the household level, choices regarding self-sufficiency in food and energy resources, changes in patterns of trade or considerations related to natural resources and ecological services. Accordingly, while there may be large possibilities in some sectors, there are a number of considerations that inhibit the actual up-take of the level of options (including cultural, social, political and economic considerations). Planners and policy makers would need to therefore give due consideration to these factors as well in making choices and delineating priorities.

CHAPTER 1 : INTRODUCTION

1.1 Background

With growing recognition of the implications of global warming, there is a grave concern particularly among policy makers and planners about identifying and adopting low carbon technology and policy measures that align with their national development objectives and sustainability concerns.

At the COP 15, the Honourable Prime Minister of Malaysia made a voluntary pledge of up to 40% reduction of Green House Gas (GHG) emissions intensity of GDP by 2020 as compared to 2005 levels, subject to availability of technology and finance. This implies that the country needs to restrict its emissions to only about 60% of 2005 GHG emissions in the production of each unit of GDP (if GDP grows at 6% p.a. during the period 2010-2020). This is a challenging task for the Malaysian economy as the country has planned for high GDP growth and a corresponding improvement in the standards of living of the people in the coming years. The land utilization patterns, mobility needs, and energy requirements could increase substantially with economic growth across various sectors of the economy.

The Ministry of Natural Resources and Environment (NRE) has awarded a study “A Roadmap of Emissions Intensity Reduction in Malaysia” to Universiti Tenaga Nasional (UNITEN). The Energy and Resources Institute (TERI) in collaboration with UNITEN has led the mitigation component of this study and is providing overall advice in terms of delineating the roadmap for Malaysia. The mitigation component of the study seeks to provide a comprehensive analysis of the mitigation potential in Malaysia and delineate strategies and mitigation measures to address the intended specific objective of achieving 40% or more reduction in GHG emissions intensity of 2005 levels by 2020 and beyond. While, the voluntary reduction in GHG emission intensity is up to 40%, the scope of this study has been enlarged to examine GHG emissions intensity reduction by 40% or more of 2005 levels by 2020 and beyond in Malaysia.

In Phase I, UNITEN and TERI had carried out a preliminary study titled “An Inception Report for The Long-term Roadmap for 40% Reduction in Emissions Intensity” for the Ministry of Natural Resources and Environment (NRE). The study had carried out a preliminary analysis of current trends in the Malaysian economy with a view to delineate the key options that could be available to Malaysia for GHG emissions reduction.

This study (Phase II) uses the learning of Phase I and has conducted further analysis to gain a deeper understanding of issues specific to the country, and to subsequently delineate a detailed roadmap for GHG emissions intensity reduction in Malaysia.

This report had laid out the overall framework for delineation of the GHG mitigation roadmap, highlighted the main issues across the key sectors in Malaysia, and presented the analysis and understanding of the mitigation options and potential for emission reduction across various sectors of the economy.

This report also presents the roadmap based on detailed analysis and examination of costs and benefits where possible, delineating and identifying the options in each of the sectors towards achieving 40% emissions intensity reduction in the country, keeping in mind the larger development objectives of the country. The report also contains an analysis of possible policy and strategy directions along with the modelling and analytical work in developing the roadmap for carbon intensity reduction.

1.2 Objective

The study is aimed to provide a long-term roadmap of the economy in achieving the carbon emission reduction covering the following objectives:

- i. To provide a comprehensive macro view of the Energy Sector, Waste Sector, Land Use, Land Use Change and Forestry (LULUCF), Agriculture and Industrial Processes to address mitigation options for GHG emissions reduction, identify opportunities for GHG emissions abatement, adaptation strategies and developing a low carbon economy technological pathway. The study covers the energy sector that comprises the power sector, transportation sector, industrial sector, residential and commercial sector, and non-energy sector comprising waste, LULUCF, agriculture and industrial processes.
- ii. To make recommendations on the steps required on adaptation measures including the costs and benefits of the proposed actions in addressing climate change covering the key impacts on water, ecosystems, food, coastal and health (In a separate report).
- iii. To identify technological interventions towards low carbon economy pathways up to and beyond 2020. The study will cover the cost of these technologies, cost effective solutions, and incentives to reduce the intended carbon emissions successfully.

Based on the costs of various alternatives and the barriers in moving to different choices, the study seeks to identify options that the country should undertake in order to move towards a low carbon pathway, and suggests specific policy interventions to guide the development along this sustainable development path.

1.3 Scope of Work

The scope of work in the Roadmap on Reduction of Emissions Intensity for Malaysia covers the mitigation sector, adaptation sector, technology needs assessment and low carbon economic pathways. The details of the scope of work for each sector will be covered in the following sections of this report.

The study is intended to provide a macro view of the energy and non-energy sector to address GHG emissions reduction, identify opportunities for GHG emissions abatement. One of the key outputs will be to present the basket options that the country will move towards achieving up to and beyond 40% reduction in emissions intensity.

The outputs of the study include the following:

- i. Trending of energy utilisation, primary energy supply, fuel mix and sectoral energy consumption patterns of the country.
- ii. Findings on GHG emission issues in Malaysia covering historical trends on the availability of fossil fuels (indigenous sources and imports) and renewable resources.
- iii. Indication of future emissions, policies and programmes that need to be considered especially from the energy and non-energy sectors comprising waste, LULUCF, agriculture and industrial processes to address the adverse impact of GHG emission on climate change.
- iv. Indicative scenario analysis that will have an economic impact on investments and costs in meeting the intended carbon reduction.
- v. Potential technological options and innovative solutions that can be adopted across the economy to achieve the carbon emission intensity target.
- vi. Recommendations on mitigation policies, programmes and practical initiatives to achieve the target emission intensity reduction covering the energy sector, waste sector, LULUCF sector, agriculture sector and industrial processes sector.
- vii. Recommendations on adaptation policies, programmes and practical initiatives to achieve the target areas covering water, ecosystems, food, coasts and health. (In a separate report).
- viii. Recommendations on technological options to achieve a low carbon economy pathway up to and beyond 2020.

1.5 Structure of the Report

The structure of this report is as follows:

Chapter 1 of the report provides an introduction and background of the study.

Chapter 2 provides an overview of the Malaysian economy as a whole in terms of laying out the characterization of the country, its socio-economic profile, and emission inventory.

Chapter 3 provides the mitigation assessment for the study. The chapter provides a comprehensive analysis for developing the mitigation roadmap for Malaysia detailing the mitigation prospects, potential and strategies across the Energy Sector, Waste Sector, Land Use, Land Use Change and Forestry (LULUCF), Agriculture and Industrial Processes sectors. This is done using an integrated analytical framework. Meanwhile, a bottom-up approach is adopted in assessing the changes in end-use demands and activity levels across sectors, specific technologies evaluation and options across sectors, and develops scenarios for energy and non-energy GHG emitting sectors to assess the potential for GHG emission reduction. The mitigation assessments in each of sectors are prepared with reference to Business-as-Usual (BAU) baseline projection from 2005 until 2030, taking into account the economic and social policies, economy and energy development trends and projections, existing and planned policies, measures and initiatives in Malaysia's economy. Based on the analysis, a mitigation roadmap for each of the key sectors is laid out in terms of suggestions for the short, medium and long term plan.

Chapter 4 provides the development of technological intervention for Low Carbon Economy Pathways (LCE). Based on the overall climate change and energy context in Malaysia, the identification and development of technologies, practices, and policies, both for mitigating GHG emissions as well as for adapting to the adverse physical impacts associated with climate change, are of key importance to avoid irreversible changes associated with dangerous levels of climate change. The increasing importance of technology issues has been reflected by the agenda of negotiations on a future climate policy regime and the need for enhanced action on technology transfer has been recognized. Therefore, this chapter provides an evaluation and selection of technological options for mitigation and adaptation.

CHAPTER 2: MALAYSIA OVERVIEW

2.1 Basic Data & Geographic Overview

Located in South East Asia, Malaysia lies between 1°N and 7°N of the equator, and 99.5°E and 120°E. The total land area of Malaysia is 329,750 km². The administrative divisions consist of Peninsular Malaysia; the states of Sabah and Sarawak; and the Federal Territory of Labuan in the north western coastal area of Borneo Island. The two regions are separated by the South China Sea. Peninsular Malaysia includes eleven states and two federal territories (Kuala Lumpur and Putrajaya). From coastal areas to mountainous regions, the topography of Peninsular Malaysia is varied. The Peninsular is dominated by a central mountainous spine extending from the north to the south, known as the Titiwangsa Range. The mountain range extends about 480km in length and is at a height of 900-2,100m above sea level.

The state of Sabah is characterised by a mountainous landscape, particularly in the west coast, while the eastern side has undulating lowland basins. The Crocker Range divides the western coastal plains from the rest of Sabah on the south of Mount Kinabalu, which is the highest mountain in Malaysia at 4,101m above sea level.

The landscape of Sarawak includes a flat coastal plain followed by a narrow belt of hills with a sharp rise of mountainous mass extending the full length of the state. Mount Murud is the highest peak at 2,423m, followed by Mount Mulu. The largest natural limestone cave system in the world lies in Mount Mulu.

Malaysia experiences relatively uniform temperatures throughout the year with the temperature in the lowlands ranging between 21°C at night and 32°C during the day, and daily mean temperatures ranging between 26°C and 28°C.

The Malaysian coastline is over 4,800km in length. The weather in the coastal regions is affected by convective rain and the distribution of rainfall is greatly influenced by topography and the monsoon winds. The country receives abundant rainfall with the average annual rainfall ranging from about 2,000 mm to 4,000 mm. The east coast of Peninsular Malaysia, north-eastern part of Sabah and southern Sarawak receive spells of heavy monsoon rainfall lasting one to three days during the northeast monsoon. The boreal summer monsoon is relatively drier. The inter-monsoon periods generally receive heavy rainfall from convective showers and thunderstorms in the late afternoon and evening.

2.2 Socio-Economic Overview

The socio-economic profile of any economy forms the basis of its development trajectory and has an important bearing not only on the level of emissions associated with its development, but also on the choices available to the country and to various user groups in the economy. Socio-economic parameters are strongly linked to levels of energy use, with population and GDP being the most relevant driving forces influencing the patterns of growth, lifestyles, production and consumption choices and consequently the related environmental implications of the same. Accordingly, it is extremely important to study the dynamics of these driving forces in order to delineate how trends in growth of these drivers may impact consumption patterns, energy choices, and consequent emission levels in the economy. The macro level drivers and demand projections are estimated up to 2035, since the energy sector analysis considers development of model till 2035 to enable analysis up to 2030.

2.2.1 Population

The objective of examining population is to understand the role of population growth as a driver of energy use and emissions, to examine differences in consumption patterns between different socio-economic groups and over time (for which classification of urban and rural population and income-wise categorization is needed), and to understand reasons for lifestyle choices and barriers to lifestyle changes (to enable future estimates of consumption patterns and associated emissions as well as appropriate policy formulation).

Since 1911, Malaysia has experienced three stages of demographic transition. Stage one of demographic transition in Malaysia began in 1911 till 1927. During this period, the birth and death rates fluctuated with low birth rate and high death rate. The highest death rate was recorded in 1918 at 52.9 per thousand persons, after which the death rate dropped sharply. Stage two took place during the period of 1928-1957. At this stage, the birth rate reached its peak at 46.2 in 1957, while death rate decreased. Beginning 1958 till present, Malaysia has entered the stage three where both birth and death rates are relatively low at around 9 and 5 respectively.¹

The crude birth rates, death rates as well as population growth for the three stages is depicted in Figure 2.1.

¹ Zarinah Mahari (2011), Demographic transition in Malaysia: The changing role of women, DOS, Achieving the Millennium development goals: EPU, Malaysia

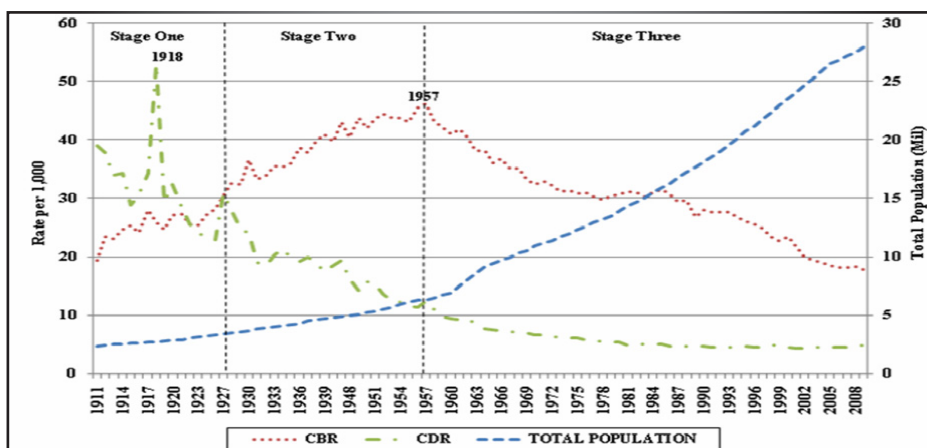


Figure 2.1: The three stages of growth in Malaysia

Source: Zarinah Mahari, 2011

The share of urban population has increased from 51.4% in 1980 to 63.4% in 2010. ETP estimates indicate that Malaysia's population would be 70% urbanized by 2030. This trend is assumed to carry on further till 2035. Figure 2.2 presents the likely population trajectory for Malaysia till 2035, based on this data.

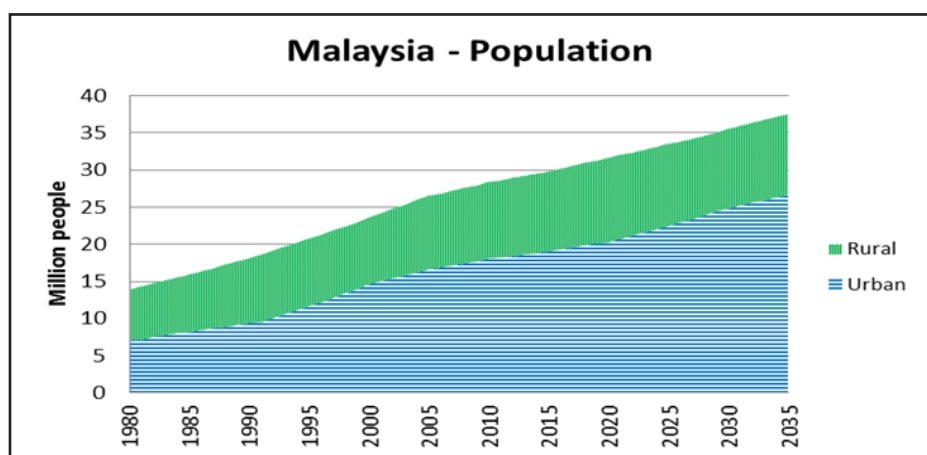


Figure 2.2: Population of Malaysia

Source: EPU, 2012

The population of Malaysia has been growing at an average rate of 2% per annum over the last 10 years. The growth rate has however been decreasing and has dropped from 2.5% per annum to a rate of 1.6% per annum. The population is expected to grow at a rate of 1.14% per annum between 2011 and 2020 (EPU, 2012). This rate is assumed to be constant for further projection till 2035.

In terms of the regional spread of population, Peninsular Malaysia has the highest level of urbanization at 66.8%, while Sabah and Sarawak are 49.3% and 49.9% urbanized respectively in 2010. However, between 2000 and 2010, the rate of increase of urban population has been the highest in Sabah (2.38%) followed by Sarawak (2.32%) and Peninsular Malaysia (2%).

Kuala Lumpur is the largest city of Malaysia and its capital with a population of 1.3 million in 2010. Other large cities include Ipoh, Klang, and, Johor Bahru. The population density of Malaysia has increased from 55 people per square kilometre in 1990 to 85 people per square kilometre in 2010. However, there are large variations in population density across different regions, with Peninsular Malaysia housing 80% of the total population.

The age structure of the population largely depends on the changing trends in fertility, mortality and migration. The age pyramid shows the changes that took place during the 1970, 1980, 1990 and 2000 in the age/sex compositions of the Malaysian population in Figure 2.3.

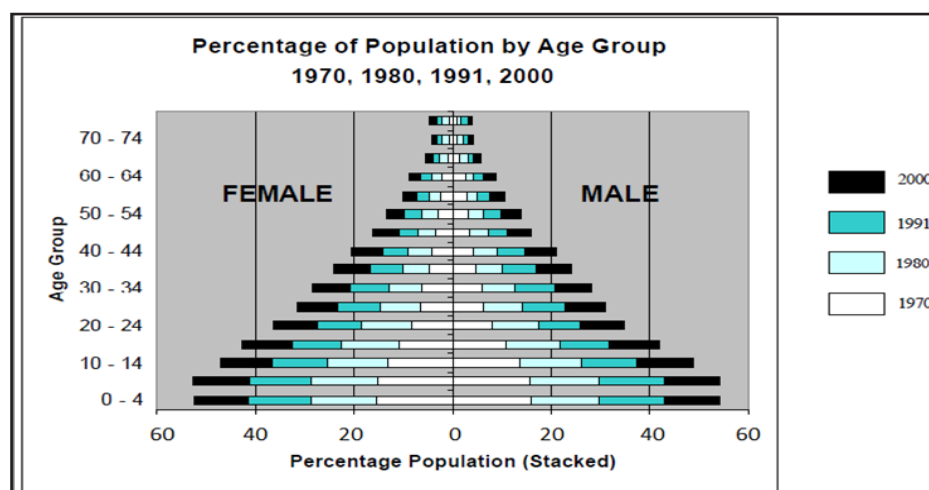


Figure 2.3: Age pyramid of Malaysia
Source: Department of Statistics, 2010

The share of the population below the age of 4 years declined from 15.9% in 1970 to 11.1% in 2000. For the males under the same age, the proportion fell from 16.1% in 1970 to 11.3% in 2000. The share of the females in the same age category fell by 4.7% in the corresponding period from 15.7% in 1970 to about 11.0% in 2000. This reflects the slowing down of the population growth with fair equity between males and females.

On the other hand, there has been a rise in proportion of population for the age group in the 25 - 44 from 21.5% in 1980 to 29.7% in 2000. This goes to show that there has been an increase in the young working population which is good news for the economy.

While there is still fair equity between males and females in Malaysia, the total sex ratio of females to males has nevertheless dropped from 993 females for every 1,000 males in 1980 to 971 females for every 1,000 males in 2000.

Malaysia has a fairly young population with 28% of the people aged below 15. Another 67% aged between 15 - 65 in 2010. As a result Malaysia also has a fairly large working population. The population is slowly aging with the number of people in the older population group increasing and the fraction of population aged above 65 years has increased from 4% to 5%. Figure 2.4 show the distribution of Malaysia's population by age.

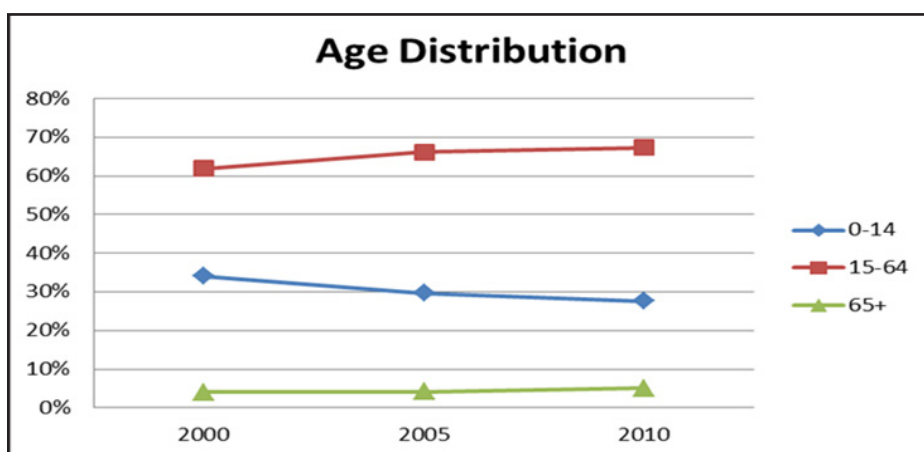


Figure 2.4: Age distribution of Malaysia

Source: Department of Statistics, 2010

2.2.2 Household

Household size has a bearing indirectly on the level of energy consumption and the size of dwelling etc. Certain end-uses show economies of scale with larger size of households, while other end-uses may be independent of household size. Accordingly, analysing trends in number and size of households is an important element in the socio-economic analysis of the country.

The rural house hold size is expected to drop from 4.6 in 2010 to 4.4 in 2030 while the urban household size is expected to drop from 4.4 in 2010 to 4.3 in 2030 (LPPKN 2010). Based on this data the average size of households at the national level is expected to drop from 4.47 in 2010 to 4.33 in 2030. The household sizes of 2030 are assumed constant till 2035.

Based on the average household size mentioned by the LPPKN for both rural and urban areas, the number of households in Malaysia has been calculated. Figure 2.5 shows the estimated number of households in Malaysia till 2035.

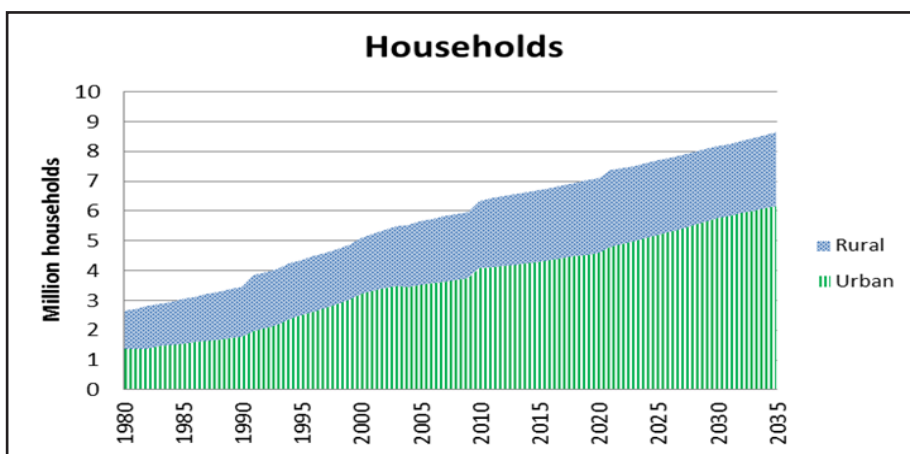


Figure 2.5: Number of households in Malaysia

Source: TERI estimates adapted from DOS, 2012

2.2.3 GDP

The GDP of an economy has a bearing on the type and level of economic activity in the country and is therefore an important consideration in analysing future development trends for Malaysia.

Malaysia has moved from being an agriculture based economy in the early 20th century to a knowledge based economy in the 1990s.

The main economic activities before 1970 were the production of rubber and tin for export and varieties of food crops. In 1970, slightly more than half of the labour force were employed in agriculture, but this has declined to 9.9% in 2000. Malaysia has been very successful in transitioning to a knowledge-based economy (K-Economy) in the mid-1990s to maintain rapid economic growth and improve competitiveness at the international level. Since 1970, Malaysia's development plans have been guided by various policies like New Economic Policy (1970-1990), National Development Policy (1990-2000) and the National Vision Policy (Vision 2020). These policies were aimed at restructuring society, eradicating poverty and ensuring redistribution of income.

The 1970s also saw a shift in Malaysia's industrialization efforts from an emphasis in import substitution in the 1960s to export promotion.

In 1977, the government introduced export financing facilities in order to provide credit facilities at preferential rates to Malaysian exporters of manufactured goods. Other promotional incentives included export allowance based on export sales and tax deductions.

The government also established industrial estates and free trade zones (FTZs) in designated areas of the country².

As a result over the years the service sector became the largest contributor to the Malaysian economy followed by the industrial sector.

Malaysia's GDP (with 2000 as base year) has grown at 5% per annum over the period 2001 to 2010. The GDP growth slowed down during the 2008 recession but has picked up again since then. The Government Transformation Programme (GTP) and Economic Transformation Programme (ETP) launched by the government in 2010 are expected to drive more private investments, and provide impetus to the development of the economy. Accordingly, the government expects to achieve a 6% growth in GDP till 2020. Further, the economy is expected to grow at an annual average rate of 5% beyond 2021 based on EPU projection.

In terms of sector wise GDP, the contribution of agriculture has dropped from 8.1% to 7.2% during 2001 to 2010. In the same time period industrial's contribution has dropped from 45.3% to 39.2% and the service sector has increased its share from 46.4% to 53.4%. Clearly, the service sector is the largest contributor and is expected to grow further according to estimated sectoral growth. The GDP growth path (at purchaser's price) for the economy is presented in Figure 2.6.



Figure 2.6: GDP growth path of Malaysia

Source: TERI estimates adapted from EPU, 2012

² Achieving the Millennium development goals: EPU, Malaysia

The sectoral GDP distribution of Malaysia is depicted in Figure 2.7.

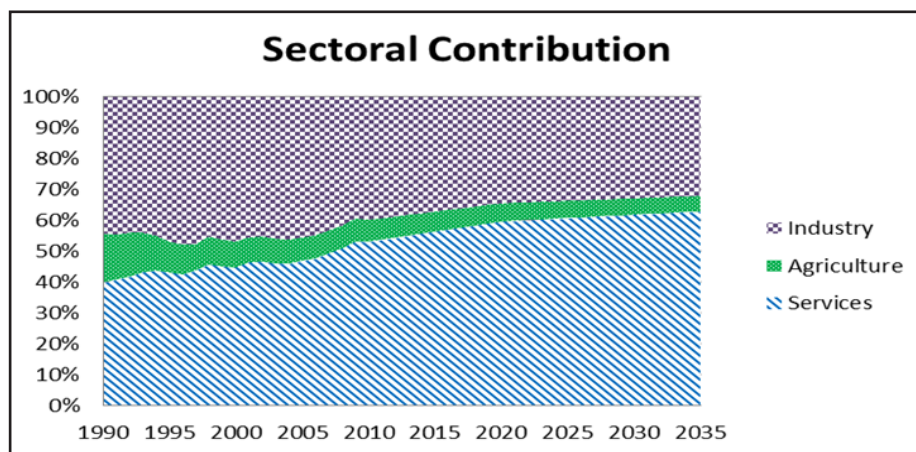


Figure 2.7: Sectoral GDP contribution

Source: TERI Estimates adapted from EPU, 2012

In the future the contribution from the services sector is expected to increase and remain the highest contributor to the economy. From the current contribution of 53%, the services sector is expected to increase its contribution to 63% by 2035. The industries and agriculture sector are then expected to make contributions of 32% and 5% respectively. The Economic Transformation Programme has envisaged various development strategies for the different sectors which have been discussed in the further sections.

2.2.4 Income per Capita

The government envisages Malaysia to become a high income nation by 2020 with a per capita income of USD 15,000 or RM 48,000 (RM 40,000 at 2000 base prices) from the per capita income of RM 23,700 (RM 19,748 at 2000 base prices) in 2010. This means achieving a per capita income growth rate of 6% per annum (ETP, 2010). The rapidly increasing trend of per capita income is likely to have implications on future demands, energy consumption patterns, consumption patterns and consequently on level of emissions.

The per capita income in Malaysia has grown at a CAGR of around 2.7% over the last ten years (2001 to 2010). Over the next two decades, taking into account GDP and population growth, it is likely that per capita income would increase at around 4.2% per annum. Figure 2.8 shows the per capita income for Malaysia as considered in this study and using GDP at purchaser's price. The rapidly increasing trend of per capita income is likely to have implications on future demands, energy use, consumption patterns and consequently on level of emissions.

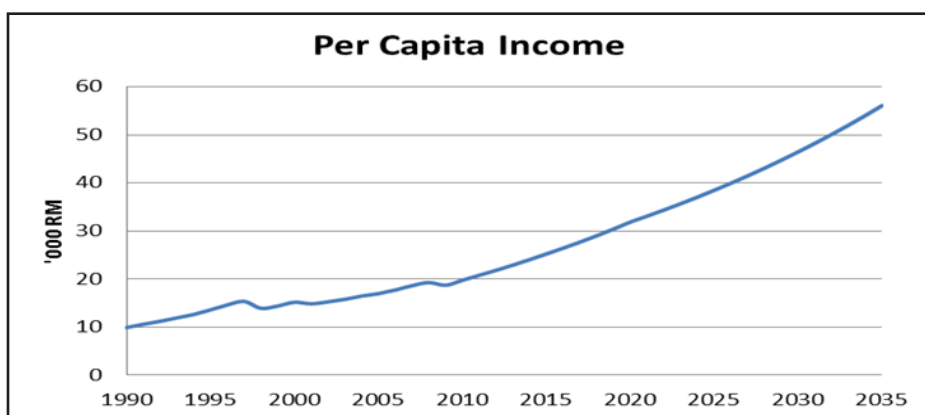


Figure 2.8: Per capita income

Source: TERI estimates adapted from DOS, 2012

Based on the estimated GDP and population growth, Malaysia would be able to achieve a per capita income of RM 30,000 (2000 base prices) by 2020 and RM 40,000 (2000 base year) only by 2026. While reaching the target of RM 48,000 or USD 15,000 per capita is desired, it is a huge challenge to achieve this even if 6% growth in GDP per annum were achieved and it is likely to remain at around 4.2% per annum.

2.2.5 Income Distribution

Overall, Malaysia has achieved higher levels of income and better income distribution with more people moving to the middle and higher income groups over time. As indicated in Figure 2.9, in 2010, 24.2% of the national population belonged to the highest income group (>RM 5,000) with around 54.3% contributing to the middle income groups (RM 1,500-RM 4,999), and the lowest three groups (up to RM 1,499), accounting for about 21.5% of the population.

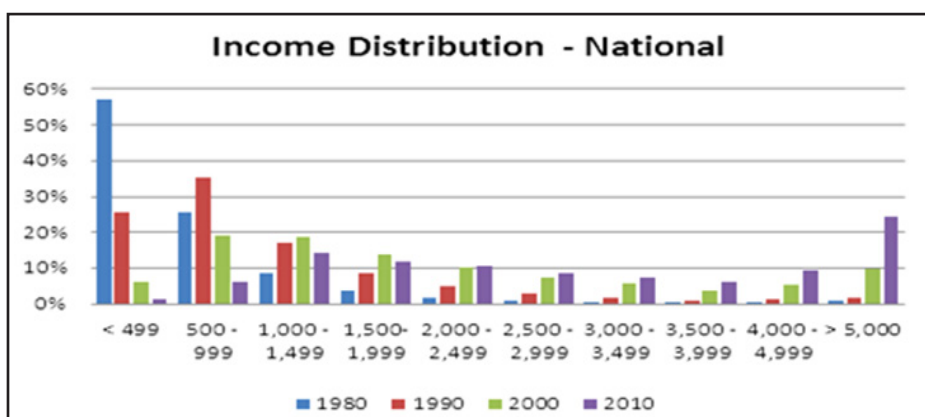


Figure 2.9: Income distributions – national

Source: Department of Statistics, 2010

While the income distribution has changed significantly for both rural and urban areas, the change in urban centres has been more drastic than in rural areas.

As indicated in Figure 2.10, in case of urban population, in 1980, around 36.5% of the population earned <RM 499 per month, and nearly 83% of the population earned <RM 1,499. The highest income category earning >RM 5,000 had only about 1.7% of the urban population. However, in 2010, around 30.6% of the urban population were in the highest income category of >RM 5,000, while the lowest three income categories (those earning <RM 1,499) had only about 14% of the population. Moreover, the middle income categories have a fairly even population distribution ranging between 7-11% in urban areas.

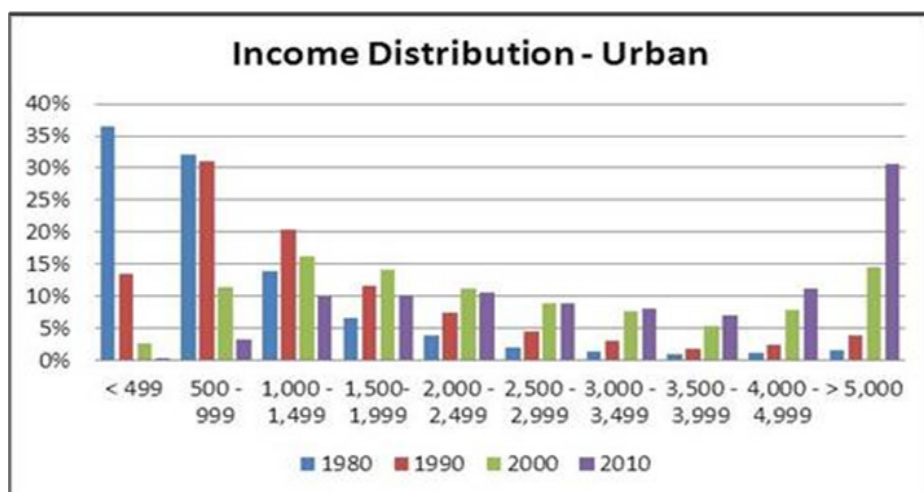


Figure 2.10: Income distributions - urban

Source: Department of Statistics, 2010

In case of rural households in Malaysia, while the situation has certainly improved, there continues to be much higher disparity than in urban areas (Figure 2.11). In 1980, 65% of the population earned <RM 499 while around 95% of the people earned less than RM 1,499. In 2010, around 39% of the rural population fell in the first three income categories earning < RM 1,499, while around 10% of the people earned >RM 5,000. While this is still a lot more than the 1980 figure of 0.3%, it certainly does not compare with the urban figure of 30.6%. Hence it is evident that, while equity and level of incomes have both improved in rural Malaysia, it is still not as good as the urban centres.

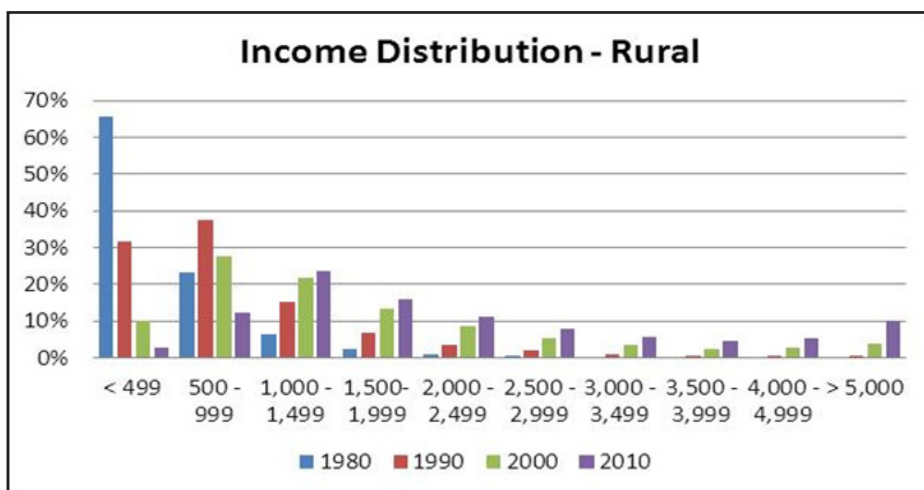


Figure 2.11: Income distributions – rural

Source: Department of Statistics, 2010

2.2.6 Social Indicators

Social indicators provide an understanding of the level of human development in the economy and lifestyles of the people, thereby affecting energy use. Therefore, some of these indicators are studied to get a better understanding of the behavioural aspects of various sections of society in Malaysia. For example, high literacy level may be associated with higher awareness about environmental issues, and lack of access to basic services and modern energy forms may have implications for future household demands as latent or “unmet demands” of certain sections of society start getting fulfilled.

Progress in human development indicators

Malaysia has achieved significant progress in human development over the years. The level of human development in Malaysia, represented by the Human Development Index (HDI) has risen from 0.599 in 1980 to 0.761 in 2011 (Human Development Report, 2011). During 1957 to 2008, life expectancy increased from 55.8 to 71.6 years for males and 58.2 to 76.8 years for females. Gender differentials in educational attainment are narrower than in the past. Concomitant with socio-economic development, the mean age at first marriage among women has increased from 21.6 years (1970) to 25.1 years (2000)³. Given that women comprise nearly half of the total labour force, their participation will contribute to the national economic growth. The female labour force participation rate has increased from 37.2% in 1970 to 45.7% in 2008.

³ Zarinah Mahari, 2011, Demographic transition in Malaysia: The changing role of women, DOS

Both rural and urban poverty rates have declined over time in the country – the incidence of poverty in rural areas declined from almost 38% in 1980 to 11% in 2002. In the urban regions on the other hand, the poverty rate fell from 12% to 2% in the same period of time. Efforts have been made to specifically target the number of households living with hard-core poverty which also declined from 2.2% to 1% over the same period of time. The National Development Programme (NDP) for the hard-core poor, launched in the NDP plan period 1991-2000 aimed at assisting these households to increase their income levels.

The literacy levels in the country are high and have been improving over time. Literacy level for the age of 10-64 years has increased from 89% in 1991 to 94% in 2000. With regard to the second MDG of primary education, Malaysia already achieved this goal in 1990 when 99% of the children were enrolled in schools. This also partly reflects the achievement of the third goal of gender equality.

However, this is not truly reflected in the change in Labour Force Participation Rates (LFPR) as the female LFPR has remained around 47% over the period 1975- 2002. Yet, there has been a movement within the kind of employment that women have been engaged in, from agriculture towards more tertiary activities. Time and again efforts have been made in the country to increase the gender empowerment. The National Policy for women is one such example, which brought about policies such as equitable sharing of resources etc. into being.

The child mortality rates of the country too, have declined significantly over time. While the infant mortality rate has fallen from 40.8 per 1000 in 1970 to 6.2 per 1000 in 2002, the under-5 child mortality has also declined by 85% over the same period (Malaysia Achieving the Millennium Development Goals, EPU).

The incidence of infection based diseases has declined markedly in the country, but diseases like cancer & cardio-vascular problems have increased. Particularly in case of HIV and AIDS, the incidence has increased markedly from 992 in 1990 to more than 58,000 in 2003. The incidence is significantly higher for males than for females.

Level of access to basic services and amenities

Access to basic services and amenities in Malaysia has improved markedly as indicated in Table 2.1. In 2008, the entire population had access to improved water sources as compared to only 88% of the population in 1990. The access to sanitation has also risen and in 2008, 96% of the people have access to improved sanitation facilities. The penetration of the Internet is at around 56% in 2008.

Table 2.1: Level of access to amenities in Malaysia

Year	Improved water source (% of population with access)	Improved sanitation facilities (% of population with access)	Internet users (per 100 people)
1990	88	84	0
1995	92	88	0
2000	97	92	21
2005	100	96	49
2010	100	96	56

Source: World Development Indicators, 2010

2.3 Response to Global Climate Change

Malaysia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in July 1994. The primary objective of this multilateral agreement is to achieve the stabilization of greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic activities from interfering with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable its development to proceed in a sustainable manner.

In terms of Articles 4.1(c), (j) and 12 of the Convention, countries are periodically required to submit reports to the Conference of Parties on various topics regarding their attempts to address climate change. In order to fulfil these requirements, Malaysia prepared an Initial National Communication in 2000 followed by the Second National Communication in 2011. Article 4.5 of that Convention identifies technology transfer as a key mechanism for addressing climate change, and requires developed countries to support technology development and utilization in developing countries.

2.3.1 Sustainable Development, Climate Change and National Priorities

Malaysia, like other developing countries, faces the dual challenge of protecting the environment while pursuing economic growth in a sustainable manner. A key concern is that climate change has the potential to undermine progress in this domain.

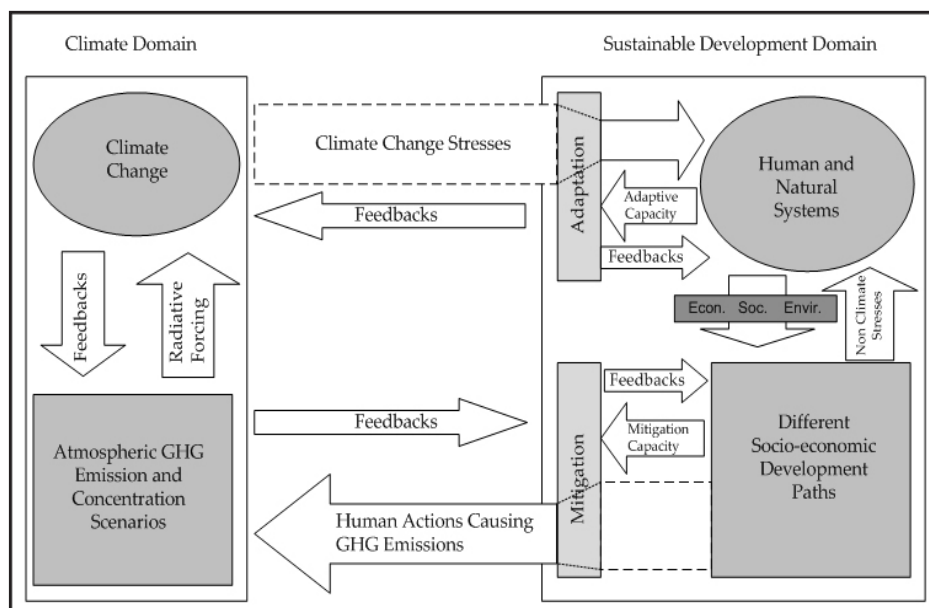


Figure 2.12: Integrated assessments modelling for analysing climate change and sustainable development linkages

Source: Adapted from IPCC 2001

The full cycle of cause and effect between climate change and sustainable development is summarized in Figure 2.12 (IPCC, 2001). Each socio-economic development path (driven by the forces of population, economy, technology and governance) gives rise to different levels of GHG emissions, which impose stresses on the human and natural systems. In this way adaptation and mitigation strategies are dynamically connected with changes in the climate system and the prospects for ecosystem adaptation, food production, and long-term economic development.

Malaysia clearly needs to place climate change at the centre of its economic policies and development projects, as it is evident that climate change and development interact in a circular fashion. The targeted sustainable development measures will entail shared and accelerated growth, appropriate interventions and community mobilization to eradicate poverty, and ensure the ecologically sustainable use of our natural resources and ecosystem services.

The Millennium Development Goals warrant the integration of sustainable development principles into country policies and programmes. The Malaysian government has initiated responses to the Millennium Development Goal targets of reversing the loss of environmental resources, increasing the numbers of its citizens who have access to safe drinking water, improving the quality of life of people living in informal settlements, addressing health issues pertaining to the eradication of major diseases, reducing infant mortality and improving maternal health. Key strategies have been developed and adopted to address biodiversity loss and development pressures on ecosystems and natural resources, and respond to the effects of an increasingly warmer and drier climate on the natural environment, communities and the economy. These include formulating the National Energy Policy (1979), National Climate Change Policy (2001), and Five Fuel Policy (2001).

2.3.2 Implication of Climate Change to Malaysia

Ecosystems in Malaysia represents a key asset contributing to the regional economy by providing food and water that sustains human life as well as natural resources such as timber and fisheries that support commercial enterprises. Degradation and loss of ecosystems pose a serious threat to the economic, social and cultural stability of the region since our community is dependent upon such ecosystems. Land-use change and degradation, over exploitation of water resources and biodiversity, and contamination of inland and coastal water have threatened many species.

Scientific assessments document that coral reef communities, mangrove wetlands, tropical and temperate forest are particularly affected. Coral reefs may be able to keep up with the rate of sea-level rise but may suffer bleaching from higher temperatures. For example, the 1997/1998 El Nino event caused widespread bleaching of coral reefs in the country especially in the East Coast of Sabah.

Landward migration of mangroves and tidal wetlands is expected to be constrained by human infrastructure and human activities. In particular, mangrove communities are affected by sea-level rise, by rainfall patterns and runoff that change the flow of freshwater to the coastal zone and, consequently, the distribution of proper saline habitat for mangroves. In particular, projected increases in evapotranspiration and rainfall variability are likely to have a negative impact on the viability of freshwater wetlands, resulting in shrinkage and desiccation.

The coastlines of Malaysia are highly vulnerable to the effects of climate change due to the geology and geography of some of the region's coastal areas, the growing density population and infrastructure in the coastal zone. Moreover, large tidal variations, tropical cyclones, coupled with the potential increase in regional rainfall, suggest the potential for increased coastal hazard.

Sea-level rise and increases in sea-surface temperature are the most probable major climate change-related stresses on coastal ecosystems. In particular, sea-level rise is the most obvious climate-related impact in coastal areas. Densely settled and intensively used low-lying coastal plains, islands, and deltas are especially vulnerable to coastal erosion and land loss, inundation and sea flooding, upstream movement of the saline/freshwater front, and seawater intrusion into freshwater lenses.

While climate change provides serious challenges to Malaysia, opportunities to optimize our progress towards more sustainable development lie in a growing awareness of the need to find more sustainable production and consumption processes, to reduce our high per capita emissions, and to respond to climate impacts through mitigation and adaptation. For example, large-scale investments in renewable energies have proven to be significant job creators in other countries, and major opportunities are generated for technology innovation and skills development. Malaysia could harness financial benefits through global funding mechanisms, including the Clean Development Mechanism, created under the Kyoto Protocol.

2.3.3 Response Option to Climate Change

Traditionally, a twin-track approach to address climate change (UNFCCC, Article 2) has been adopted, comprising mitigation and adaptation measures. Both seek to avoid the potential damages of global climate change, as well as to support the developmental needs of present and future generations in a sustainable manner. For a long time, adaptation has been treated as a marginal option in comparison to mitigation by scientists and decision-makers worldwide (Kane and Shogren, 2000; IPCC, 2001). In recent years, however, it has become apparent that regardless of how effectively precautionary measures are taken by the global community to mitigate anthropogenic GHG emissions, a non-negligible degree of global climate change is unavoidable due to the long lifespan of GHGs in the atmosphere and the inertia of the climate system (IPCC, 2001). Therefore, despite the most strenuous efforts to move to a low carbon economy, the effects of climate change due to past activity will continue to be felt, and so it is imperative that society plans to adapt to them (Munasinghe and Swart, 2005). For developing countries like Malaysia, adaptation to climate change will have considerable effect on our quality of life over the long term.

2.3.4 Role of the Ministry of Natural Resources and Environment

The Ministry of Natural Resource and Environment (NRE) are the agency responsible to lead the sustainable management of natural resources and conservation of environment. The vision and mission of the Ministry is as follows:

VISION

To lead in sustainable management of natural resources and conservation of environment towards achieving national vision.

MISSION

To provide exceptional services in management of natural resources and conservation of environment in line with the national vision through:

- i. Integrated planning of activities and programmes by the departments and agencies.
- ii. Optimization of manpower utilization, hi-end technologies and financial resources.
- iii. Maximization of natural resources development in order to support value added activities.
- iv. Enhancement and reinforcement of research and development activities.
- v. Effective dissemination and sharing of technical inputs and database management.
- vi. Effective cooperation among public, private and international sectors.
- vii. Enhancement of expertise and knowledge through effective and systematic training modules.

The preparation of TNA, and the Low Carbon Economy (LCE) policy that will be developed, will be under the purview of the NRE. The ministry is also responsible for other issues relating to climate change which includes the mitigation and adaption assessment reports through its National Communication report to the UNFCCC.

The government of Malaysia with its various ministries is responsible for the custodian of federal policies in the country. With the NRE at the helm for National Policy on Climate Change (2009), horizontal and vertical integrations with other policies is inevitable to ensure the objectives of the policies are met. Therefore, closely related ministries would include the Ministry of Energy, Green Technology and Water (MEGTW), Ministry of Science, Technology and Innovation (MOSTI), Ministry of Housing and Local Government (MHLG) together with local governments and agencies, Ministry of Transport (MoT), Ministry of Works, and Ministry of Rural and Regional Development. The Ministries involved will be monitored by National Green Technology and Climate Change Council chaired by the Prime Minister.

2.4 National Policy on Climate Change

Since the ratification of UNFCCC in July 1994, Malaysia has established a National Steering Committee on Climate Change in the same year to guide the national response on climate change in the country. Malaysian government has committed to ensure the climate change issues will be handled sufficiently and committed to deliver an Initial National Communication (NC) in 2000 and Second National Communication (NC2) in 2011.

In January 2008, Cabinet Committee on Climate Change, which is chaired by the Honourable Prime Minister, has been established and entrusted to come out with the formulation of National Policy on Climate Change in 2009. The committee has endorsed a framework of National Climate Change Policy as shown in Figure 2.13 below:

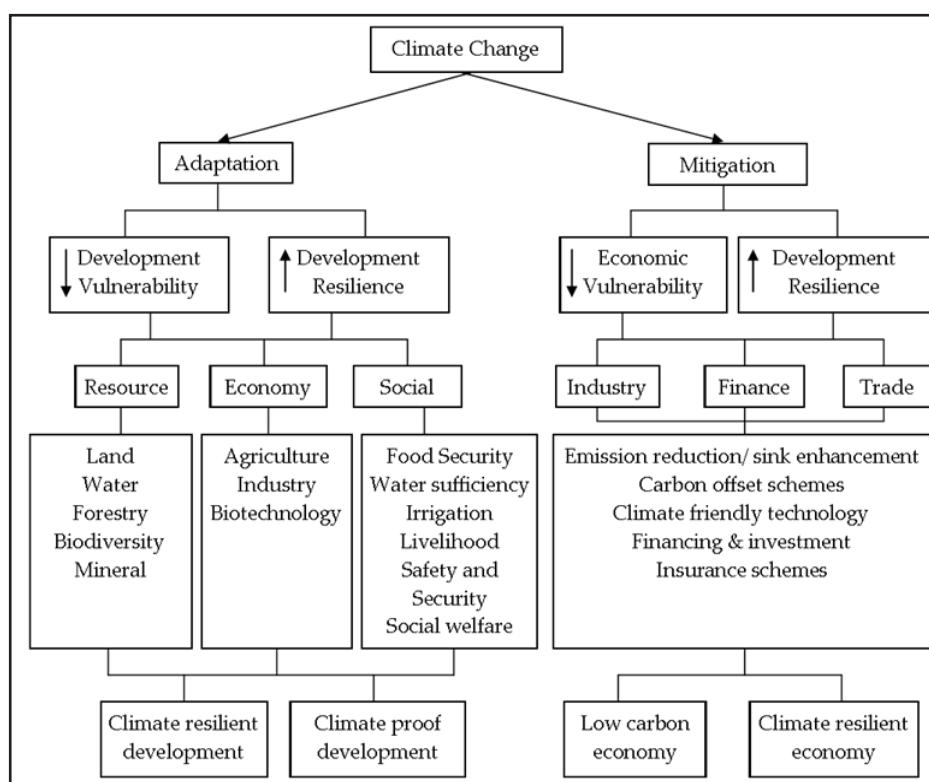


Figure 2.13: Overall framework on climate change

Source: LESTARI, 2008

The objectives of the National Policy on Climate Change (2009) are:

- i. Mainstreaming climate change through wise management of resources and enhanced environmental conservation resulting in strengthened economic competitiveness and improved life quality
- ii. Integration of responses into national policies, plans and programmes to strengthen the resilience of development from arising and potential impacts of climate change; and
- iii. Strengthening of institutional and implementation capacity to better harness opportunities to reduce negative impacts of climate change.

The formulations of the objectives in the climate change policy are based on 5 principles:

- i. **Development on a Sustainable Path** - Integrate climate change responses into national development plans to fulfil the country's aspiration for sustainable development.
- ii. **Conservation of Environment and Natural Resources** - Strengthen implementation of climate change actions that contribute to environmental conservation and sustainable use of natural resources.
- iii. **Coordinated Implementation** - Incorporate climate change considerations into implementation of development programmes at all levels.
- iv. **Effective Participation** - Improve participation of stakeholders and major groups for effective implementation of climate change responses.
- v. **Common but Differentiated Responsibilities and Respective Capabilities** - International involvement on climate change will be based on the principle of common but differentiated responsibilities and respective capabilities.

The National Policy on Climate Change will facilitate the integration of climate change considerations into planning and implementation of development programmes and decision-making processes, to foster sustainable economic and human development, as well as environmental conservation. It complements existing policies and takes cognizance of international conventions on global concerns. National responses on climate change in all sectors will be directed towards the strategic thrusts that have been set by the committee. The strategic thrusts for the National Policy on Climate Change are as follows:

- i. Facilitate the harmonization of existing policies to address climate change adaptation and mitigation in a balanced manner.
- ii. Institute measures to make development climate-resilient through low carbon economy to enhance global competitiveness and attain environmentally sustainable socio-economic growth.
- iii. Support climate-resilient development and investment including industrial development in pursuit of sustainable socio-economic growth.
- iv. Adopt balanced mitigation and adaptation measures to strengthen environmental conservation and promote sustainability of natural resources.
- v. Consolidate the energy policy incorporating management practices that enhances renewable energy (RE) and energy efficiency (EE).
- vi. Institutionalize measures to integrate cross cutting issues in policies, plans, programmes and projects in order to increase resilience to climate change.

2.4.1 State of Emission in Malaysia

According to NC2, Malaysia's GHG emissions is estimated at 223 MtCO₂ eq. in year 2000 and removal is 249.8 MtCO₂ eq. The net emissions after accounting for sink is -26.8 MtCO₂ eq., thus indicating that Malaysia was a net sink in year 2000 as shown in Table 2.2.

Table 2.2: Emissions and removal of greenhouse gas for each sector in 2000

Sectors		Emissions (Gg)	GWPs	CO ₂ eq (Gg)
Energy	CO ₂	125,005	1	125,005
	CH ₄	1,047	21	21,987
	N ₂ O	0.03	310	9
Sub-total				147,001
Industrial Processes	CO ₂	13,690.00	1	13,690
	CH ₄	4.28	21	89.88
	N ₂ O	0.66	310	204.6
	HFC	0.11	1,300	143
	SF ₆	0.00026	23,900	6.2
Sub-total				14,133.7
Agriculture	CH ₄	153.33	21	3,220
	N ₂ O	8.66	310	2,686
Sub-total				5,906
Land Use Land Use Change and Forestry*	CO ₂ (Emissions)	28,750	1	28,750
	CO ₂ (Sink)	-249,784	1	-249,784
	CH ₄	36.3	21	762.3
	N ₂ O	0.25	310	77.50
Sub-total				29,589.8
Waste	CH ₄	1,255.1	21	26,357.1
Sub-total				26,357.1
Total (emissions only)				222,987.5
Net Total (after subtracting sink)				-26,796.5

(-): indicates sink.

Note: 1 Million tonne (Mt) = 1000 Gigagram (Gg)

Source: NC2, 2011

A total of 167.5 MtCO₂ eq. was emitted for 2005. The CO₂ emissions from energy industries was the highest at 58.5 MtCO₂ eq. (35%) followed by emissions from transport (21%) as shown in Figure 2.14. Emissions from energy industries are due to the fuel used by the power and auto producers for producing electricity, petroleum refining and natural gas transformation. Manufacturing industries & construction is the third largest contributor to CO₂ emissions (16%). Forest and grassland conversion is the fourth at 14%.

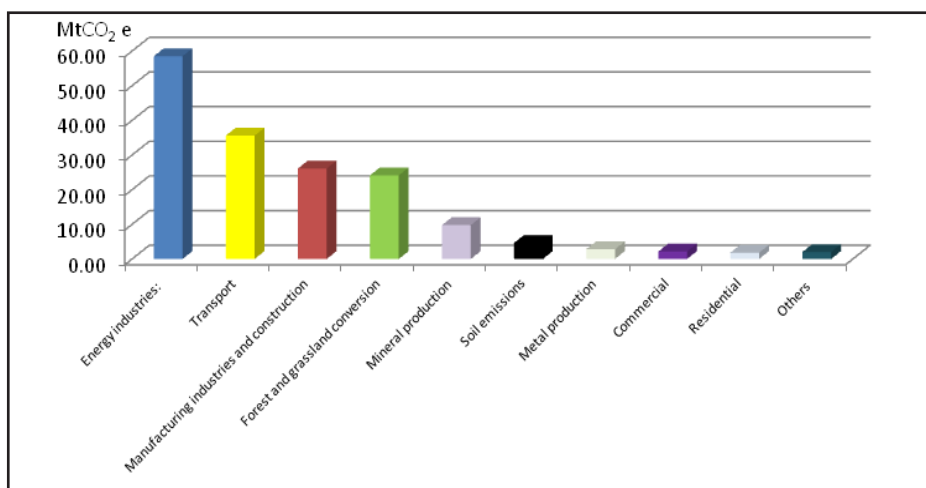


Figure 2.14: Major sources of CO₂ eq. emissions

Source: NC2, 2011

Time series emissions for energy, agriculture and waste sectors are shown in Figures 2.15, 2.16 and 2.17. The trend in the Energy sector emissions follows the GDP trend of the country (NEB, 2007). The increasing trend in the waste sector is mainly due to an increase in solid waste generation arising from population growth (NC2, 2011).

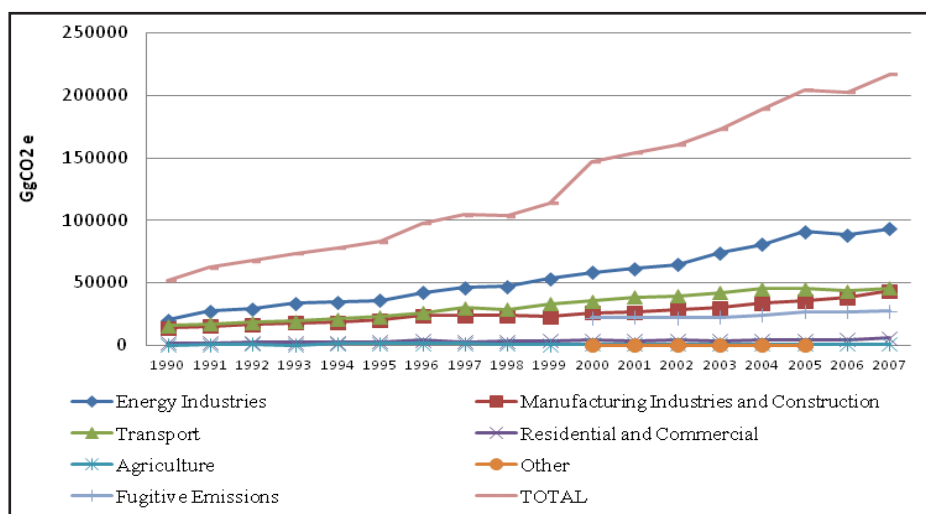


Figure 2.15: Time series emission between 1990 to 2007 for various sub- sectors within energy sector

Source: NC2, 2011

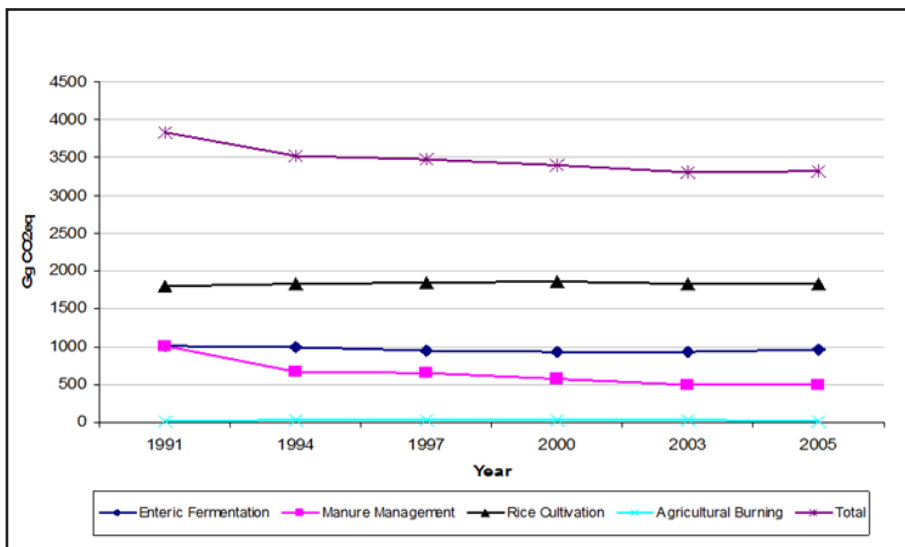


Figure 2.16: Time series emissions between 1991 to 2005 for agriculture sector
Source: NC2, 2011

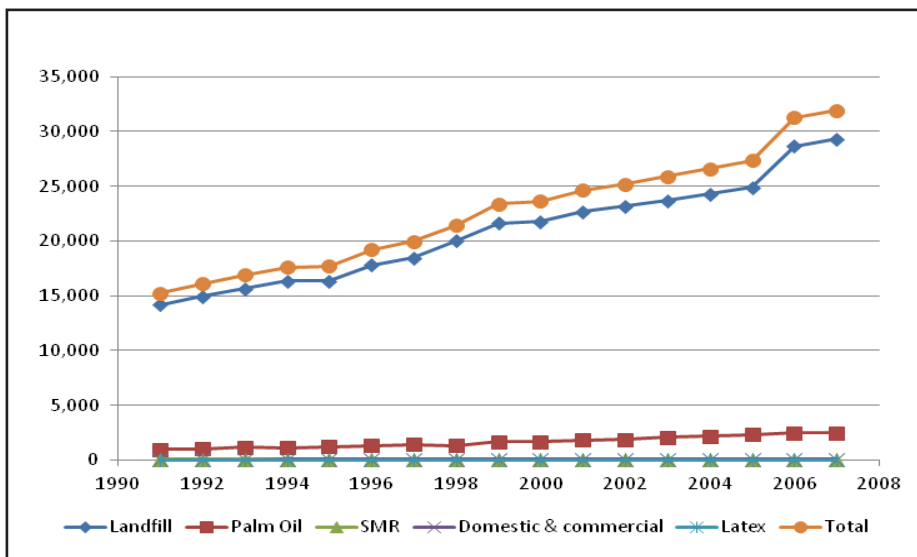


Figure 2.17: Time series emissions between 1991 to 2007 for waste sector
Source: NC2, 2011

Greenhouse gas emissions trends for 2000, 2005 and 2007 are shown in Table 2.3. In the year 2000, Malaysia was a net sink but in 2005 Malaysia became a net emitter. The change from net sink to net emitter is due to the significant increase in GHG emissions from the Energy sector, while LULUCF's sink capacity has stabilized. The rates of forest conversion have also decreased as indicated by the reduction in emissions from LULUCF.

Table 2.3: Greenhouse gas emissions trend for years 2000, 2005 and 2007

Sector / Year	Emissions/Removal (MtCO ₂ eq.)		
	2000	2005	2007
Energy	147	204.3	217.0
Industrial Processes	14.1	15.6	17.1
Agriculture	6.0	6.6	7.2
LULUCF	29.6	25.3	19.7
Waste	26.4	27.4	31.9
Total emissions	223.1	279.2	292.9
Total sink	-249.8	-240.5	-247
Net total (after subtracting sink)	-26.7	38.7	45.9

Source: NC2, 2011

The expanding energy demand is expected to cause an increase in the anthropogenic Greenhouse Gases in Malaysia. In 2000 the total anthropogenic GHG emissions for Malaysia was 223 MtCO₂ eq. as depicted in Figure 2.18, where energy sector accounted for 66% share of the total, followed by the land use, land use change and forestry sector (13%), waste sector (12%), industrial processes (6%) and agriculture (3%).

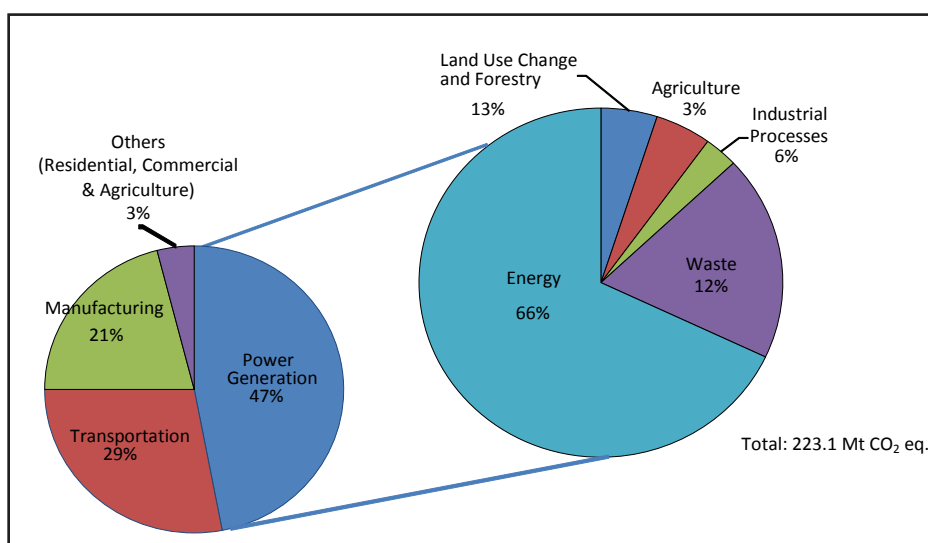


Figure 2.18: Greenhouse gases Emissions by Source, 2000

Source: NC2, 2011

Within the energy sector, the power generation sector was the highest emitter of CO₂ eq. (47%), followed by the transportation sector (29%), manufacturing industries (21%) and the remaining contributors were from other sectors (commercial, residential and agriculture) (3%). This situation was due to the high dependency of the energy sector on fossil fuels. It is expected that the GHG emissions will continue to rise in tandem with the growing demand for fossil fuel particularly in the energy sector.

2.4.2 Mitigation Assessment

The mitigation assessments that have been conducted in NC2 are for energy sector, LULUCF, waste and agriculture sector.

Based on the assessment in NC2, for the energy sector, the BAU projections are compared against the alternative scenario of Renewable Energy (RE) and Energy Efficient (EE) measures that can be implemented by the government. If the measures are proved to be successful, it is expected to reduce the CO₂ emission by 234.1 MtCO₂ eq. by 2020 (NC2, 2011).

For the waste mitigation, given the assumptions of increasing recycling rate of 22% with some introduction of material recovery facilities and thermal treatment plant for methane capture, it is expected that the full implementation of these measures will reduce CO₂ emission by 58% to 18.1 MtCO₂ eq. from 42.8 MtCO₂ eq. for BAU scenario (NC2, 2011). The summary for the mitigation assessment and options for other key sectors as recommended in NC2 are summarized in Table 2.4 below.

Table 2.4: Potential mitigation options in key sectors

Sector	Sector Potential Mitigation Options
Energy	• Implementation of RE for power generation • Implementation of EE in the industrial, commercial and residential sector • Implementation of RE in industrial, commercial and residential sector • Transportation – Hybrid & electric vehicles, integrated transportation system, bio fuels, low carbon petrol & diesel
LULUCF	• Maintain existing forest cover • Reduce emission from forest and land use related activities • Where appropriate, increase existing forest cover
Waste	• Encourage methane capture facilities at new sanitary landfills • Encourage palm oil millers to capture biogas for power generation • Encourage composting of organic waste, especially food waste and 3R (Reduce, Reuse and Recycle)
Agriculture	• Rice Management with water saving production: Intermittent flooding Aerobic rice • Livestock waste management through Aerobic manure composting Biogas capture • Partial replacement of synthetic Nitrogenous Fertilizer
Industrial Processes	• Employ new processes and materials to reduce clinker use in cement production

Source: NC2, 2011

2.5 National Policy Measures

Policies related to climate change of Malaysia will be discussed in this section.

2.5.1 Energy Policy

The following constitute Malaysia's energy policy:

- i. National Petroleum Policy (1975)
- ii. National Energy Policy (1979)
- iii. National Depletion Policy (1980)
- iv. The Four Fuel/Diversification Policy (1981); and
- v. Five Fuel Policy (2001)

I. National Petroleum Policy (1975)

The National Petroleum Policy was formulated with the objective of bringing about the efficient utilisation of this resource for industrial development as well as ensuring that the nation exercises majority control over the management and operation of the industry. The cornerstone of Malaysian petroleum policy were dictated in the Petroleum Development Act (PDA) of 1974 and the National Petroleum Policy of 1975. This legislation aimed to regulate the oil and gas industry to achieve economic development needs. It outlined the following policy goals:

- i. Making sure adequate energy supplies at reasonable prices are available to support national economic development objectives;
- ii. Promoting greater Malaysian ownership and providing a favourable investment climate.
- iii. Creating opportunities for downstream industries; and
- iv. Developing oil and gas resources at a socially and economically optimal pace, while conserving these non-renewable assets and protecting the environment.

The PDA established PETRONAS as a state-owned enterprise with exclusive ownership, exploration and production rights. It comes under the direct purview of the Prime Minister and is responsible for planning, investment and regulation of all up-stream activities. The PDA also introduced a system of Production Sharing Contracts (PSCs) to replace the previous system of concessions. The oil and gas sector was streamlined to ensure greater Malaysian participation in the ownership, management and control of oil and gas resources and activities.

II. The National Energy Policy (1979)

The National Energy Policy can be broadly defined in terms of three policy objectives as follows:

- i. The Supply Objective: To ensure the provision of adequate, secure and cost-effective energy supplies by developing indigenous energy resources, both non-renewable and renewable, using least-cost options, and diversifying supply sources both within and outside the economy;
- ii. The Utilisation Objective: To promote the efficient utilisation of energy and the elimination of wasteful and non-productive patterns of energy consumption; and
- iii. The Environment Objective: To minimize the negative impacts of energy production, transportation, conversion, utilisation and consumption on the environment.

III. The National Depletion Policy (1980)

The National Depletion Policy of 1980 was formulated to prolong the life of the economy's oil and gas reserve. The policy, aimed at major oil fields of over 400 million barrels of oil initially in place (OIIP), restricted production to 1.75 percent of OIIP. However, the initial restriction proved too conservative, and in 1985, the ceiling was raised to 3 percent of OIIP. Due to this policy, total production of crude oil was limited to about 650,000 barrels per day. The National Depletion Policy was later extended from crude oil to include natural gas reserves. An upper limit of 56.6 MCM per day (2,000 million standard cubic feet per day) has been imposed in Peninsular Malaysia.

IV. Four-Fuel Policy (1981)

To complement the National Depletion Policy and ensure the reliability and security of supply, the government adopted the Four-Fuel Policy. This strategy was designed to reduce the economy's dependence on oil, and its goal was to achieve an optimum mix of oil, gas, hydropower and coal in the supply of electricity.

As much as possible, development of domestic resources were encouraged to enhance security of supply. Under this initiative, oil share had fallen significantly. Consumers, particularly the power sector, had substituted oil with natural gas, which was available domestically and was environmentally friendly compared with other fossil fuels. In year 2000, natural gas share in the fuel mix for power generation was 78.7% while hydro, coal and oil were 8.0%, 7.9% and 5.3% respectively. Too much dependent on natural gas was seen just as risky as being too dependent on oil in the 1970s. To reduce heavy reliance on natural gas the government had turned to coal as a major fuel in the country's fuel mix. In 2010, currently the coal represents 31.4% of the fuel mix (EC, 2012).

V. Five-Fuel Policy (2001)

The policy was formulated under the 8th Malaysia Plan (2000-2005) to encourage the utilization of renewable resources such as biomass, solar, mini hydro, etc. as an additional source of electricity generation. To fast track the implementation of the Five-Fuel Policy, the Government launched the Small Renewable Energy Power Programme (SREP) in May 2001. Under this programme, the utilization of all types of RE sources including biomass, biogas, municipal solid waste, solar, mini hydro and wind were allowed. Besides the launching of SREP, there were a few more initiatives taken by the government to promote RE including the implementation of Biomass-based Grid Connected Power Project and Malaysian Building Integrated Photovoltaic Project.

Table 2.5 and Table 2.6 summarizes the various key energy policies and plans over the last three decades.

Table 2.5: Energy-associated government policies and plans

Policy/act	Key emphasis
National Petroleum Policy (1975)	Introduced to ensure optimal use of petroleum resources and regulation of ownership, management and operation, and economic, social, and environmental safeguards in the exploitation of petroleum due to fast growing petroleum industry in Malaysia.
National Energy Policy (1979)	- Formulated with broad guidelines on long-term energy objectives and strategies to ensure efficient, secure and environmentally sustainable supplies of energy. It has three main objectives: - Supply objective: To ensure the provision of adequate, secure, and cost-effective energy supplies through developing indigenous energy resources both non renewable and renewable energy resources, using the least cost options and diversification of supply sources, both from within and outside the country. - Utilization objective: To promote the efficient utilization of energy and to discourage wasteful and non-productive patterns of energy consumption. - Environment objective: To minimize the negative impacts of energy production, transportation, conversion, utilization and consumption on the environment.
National Depletion Policy (1980)	Introduced to safeguard against over exploitation of oil and gas reserves. Thus, it is a production control policy.
Four Fuel Diversification Policy (1981)	Designed to avoid over-dependence on oil as main energy supply for electricity and aimed at placing increased emphasis on gas, hydro and coal in the energy mix.
Electricity Supply Act (1990)	Regulates the licensing of electricity generation, transmission and distribution.
Gas Supply Act (1993)	Regulates the licensing of the supply of gas to consumers through pipelines, prices, the control of gas supply pipelines, installations and appliances as well as safety.
Five Fuel Diversification Policy (2001)	Introduced in recognition of the potential of biomass, biogas, municipal waste, solar and mini hydro as potential renewable energy resources for electricity generation.

table continues...

Policy/act	Key emphasis
Energy Commission Act (2001)	- The Energy Commission (or Suruhanjaya Tenaga) was established to provide technical and performance regulation for the electricity and piped gas supply industries, as the safety regulator for electricity and piped gas and to advise the government on matters relating to electricity and piped gas supply including energy efficiency and renewable energy issues. - The Electricity Supply Act 1990 and Gas Supply Act 1993 have both been amended to allow the Energy Commission to take over these responsibilities
National Biofuel Policy (2006)	- Supports the five fuels diversification policy. Aiming at reducing the country's dependence on depleting fossil fuels. - Promote the demand for palm oil. Five key thrusts: transport, industry, technologies, export and cleaner environment. Highlights: - Produces a biodiesel fuel blend of 5% processed palm oil with 95% petroleum diesel. - Encourage the use of biofuel by giving incentives for providing biodiesel pumps at fuelling stations. - Establish industry standard for biodiesel quality under Standards and Industrial Research Institute of Malaysia (SIRIM). - Set up of a palm oil biodiesel plant.
The National Green Technology Policy (2009)	- Intensification of Green Technology research and innovation towards commercialization. - Promotes and creates public awareness of Green Technology. - Promotes Green Building Index. - Promotes application of RE in commercial and residential buildings such as PV, rainwater harvesting, phasing out of incandescent lights.
National Policy on Climate Change (2009)	- ST5-P2: Consolidate the energy policy incorporating management practices that enhances renewable energy (RE) and energy efficiency (EE). - KA19 - ST5 : Promote RE and EE for power generation through: - Burden sharing between government and power producers; - Establishment of EE and RE targets/standards; - Inclusion of RE in generation mix by power producers; and - Promotion of RE generation by small and independent developers including local communities
National Renewable Energy Policy and Action Plan (2009)	- 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 generation - To enhance awareness on the role and importance of RE
Renewable Energy Act (2011)	Provides for the establishment and implementation of a special tariff system to catalyse the generation of renewable energy and to provide for related matters.
Sustainable Energy Development Authority Act (2011)	Provides for the establishment of the Sustainable Energy Development Authority of Malaysia and to provide for its functions and powers and for related matters.

Table 2.6: Malaysia's key emphasis from 7th MP to 10th MP for energy development

Malaysia plan	Key emphasis
Tenth Malaysia Plan (10th MP) (2011–2015)	- Increases public awareness and commitment for the adoption and application of green technology through advocacy programmes. - 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. - Increases foreign and domestic direct investments (FDIs and DDIs) in green technology manufacturing and services sector. - Expands local research institutes and institutions of higher learning to expand research, development and innovation activities on green technology towards commercialization through appropriate mechanisms. - Launching New RE act and FiT mechanism. - Accelerates the implementation of energy efficiency initiatives in the industrial, commercial, residential and transport sectors.
Ninth Malaysia Plan (9th MP) (2006–2010)	- Emphasise on strengthening initiatives for EE especially in transport, commercial and industrial sectors, and in government buildings. - Encourages better utilization of RE through diversify fuel sources - Intensifies efforts to further reduce the dependency on petroleum provides for more efforts to integrate alternative fuels. - Further enhancement for incentives in promoting RE and EE.
Eighth Malaysia Plan (8th MP) (2001–2005)	- Emphasises on the sustainable development of energy resources, both depletable and renewable. The energy mix includes five fuels: oil, gas, coal, hydro and RE. - Intensifies efforts on ensuring adequacy, quality and security of energy supply. - Greatly emphasise on EE: encourage efficient utilization of gas and RE as well as provide adequate electricity generating capacity. - Supports the development of industries in production of energy-related products and services. Highlighted in promoting RE and EE: i. Incentives for EE. ii. Incentives for the use of RE resources. iii. Incentives to maintain quality of power supply
Seventh Malaysia Plan (7th MP) (1996–2000)	- Emphasises on the sustainable development of depletable resources and the diversification of energy sources. - Ensured adequacy of generating capacity as well as expanding and upgrading the transmission and distribution infrastructure. - Encourages the use of new and alternative energy sources as well as efficient utilization of energy.

2.5.2 National Environment Policy

Malaysia's overall environmental policy objectives, since the Third Malaysian Plan (1976-1980), have always intended to balance the goals of socio-economic development and the need to bring the benefits of development to a wide spectrum of population, keeping in mind the maintenance of sound environmental conditions. Furthermore, the National Development Policy of the Second Outline Perspective Plan (1991-2000) categorically states "adequate attention will be given to the protection of the environment and ecology so as to maintain the long term sustainability of the country development."

In line with the above, the Malaysian Government through the Department of Environment has formulated its vision, that is, to contribute towards nation building in attaining a better level of health, safety and quality of life through conservation and preservation efforts, prevention and control of pollution, protection and promotion of wise use of natural resources towards sustainable development for present and future generations.

In short, the objectives of environmental management in Malaysia continue to be based on fundamental policy directives elucidated in the Malaysian Plan, and as follows:

- i. To maintain a clean and healthy environment;
- ii. To maintain the quality of the environment relative to the needs of the growing population;
- iii. To minimize the impact of the growing population and human activities relating to mineral exploration, deforestation, agriculture, urbanization, tourism and the development of other environmental resources;
- iv. To balance the goal for socio-economic development and the need to bring the benefits of development to a wide spectrum of the population, keeping in mind the maintenance of sound environmental conditions
- v. To place more emphasis on prevention through conservation rather than on the curative measure, inter alia by preserving the country's unique and diverse cultural and natural heritage; and
- vi. To incorporate an environment dimension in project planning and implementation, inter alia by determining the implications of the proposed projects and the cost of the required environmental mitigation measures.

CHAPTER 3: MITIGATION ASSESSMENT

3.1 Introduction

3.1.1 Methodology and Approach

The Mitigation sector will delineate a roadmap for reducing GHG emissions intensity by 40% or more of 2005 levels by 2020 and beyond in Malaysia. It involves evaluation and prioritization of key options for energy and non-energy sectors, and suggests policies and strategies for catalysing efforts towards resource efficient utilization of energy and GHG emission reduction in key sectors in Malaysia.

A bottom up approach is adopted for the mitigation study, which considers the evaluation of options within an integrated analytical framework. Figure 3.3.1 provides a schematic representation of the framework and key steps in the overall approach. The analysis time frame of this study is from 2005 to 2030.

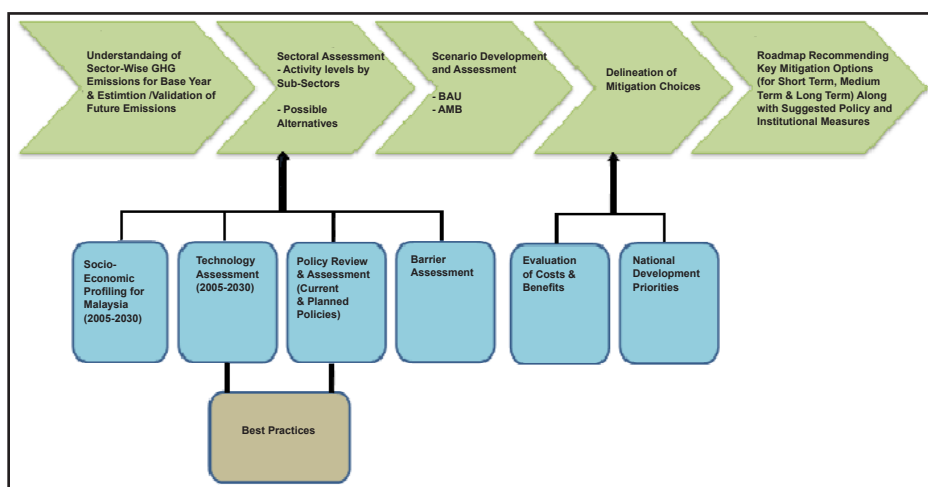


Figure 3.1.1: Schematic of the analytical framework

The key steps within this approach include:

- i. Understanding of sector-wise GHG emissions for the base year (2005) and estimation/ validation of future emissions
- ii. Sectoral assessment of activity levels by sub-sectors
- iii. Scenario development and assessment (BAU vs. Alternative scenarios)
- iv. Delineation of mitigation choices
- v. Roadmap recommending key mitigation options for the short, medium & long term along with suggested policy and institutional measures

The approach involves the development of scenarios for energy and non-energy GHG emitting sectors, assessment of changes in end-use demands, and evaluation of specific technologies and options that can satisfy end use demands for energy and non-energy services associated with GHG emission. Separate sector-wide models are used for energy, land use, land-use change & forestry (LULUCF), and agriculture sector assessment. While the different sector models are not hard linked, they provide inputs to each other and use a consistent methodological approach and a common and consistent set of macro assumptions.

The first step involved collection of data from secondary sources for the base year (and past years) on the activities and technologies/practices that are associated with GHG emissions or carbon storage. The types of data and the levels of detail available vary from one sector to the other. In each case however, the assembly of base year data draws on and is consistent with the national GHG emissions inventory.

Based on the understanding of activities and related emissions in the base year, the next step includes an evaluation of how the future is expected to unfold. The projection of the future levels of activities in each sector is based on assumptions related to trends in basic drivers such as population, GDP, and other macro variables. The assumptions about these basic drivers remain the same across all sectoral assessment models.

For each type of activity or resource demand, there are generally a number of technologies or practices that can be employed and they have different implications for resource use and GHG emissions or carbon storage. Moreover, each of these technologies may face several barriers. Assessments of likely future emissions in each sector depends on activities and technologies/options that result in GHG emissions or that shape opportunities for carbon storage.

Accordingly, an attempt is made to conduct an activity-wise disaggregation in each sector to examine in greater detail the existing and potential options in each sector that could reduce GHG emissions or sequester carbon. Across each of the sectors, technologies and practices are sought to be examined with reference to their techno-economic parameters such as cost, useful life, performance, efficiency, environmental characteristics, etc, to enable a comparative evaluation of options in the future. Emphasis has been placed on locally derived data. The primary data sources that have been used include the existing energy balances, industry-specific studies, household energy surveys, data on fuel supply, etc. The main thrust of the data collection effort is not so much on collecting new primary data but on collating secondary data and establishing a consistent data set suitable for analysis within the selected framework.

Future scenarios also take into account current and likely policies that have a bearing on activities and technologies/options in each sector. These include policies affecting pricing of energy sources, energy efficiency programmes, renewable energy portfolio programmes, policies influencing diffusion of new technologies, land use patterns, policies that impact forestry and waste sectors and policies related with structural changes, national development priorities, etc.

Because the range of technologies and practices that could reduce GHG emissions or sequester carbon are large, further analysis and screening of the potential technology options in the Malaysian context is carried out to prioritise the options.

In case of data gaps, local data is supplemented with judiciously selected data from other countries. For example, current and projected cost and performance data for some mitigation technologies may not be available locally, particularly if the technologies are not currently in wide use.

Assessment of scenarios includes the development and analysis of a Business as Usual (BAU) scenario and alternative scenarios. The BAU scenario is a description of a plausible future in which no specific climate change policies are considered. The ambitious (AMB) scenarios examine the implications of possible mitigation pathways by including transitions to efficient technologies, fuel substitution and undertaking of options that decrease emissions as compared to the BAU trajectory. The alternative scenarios are similar to the BAU scenario with respect to overall economic and social trends, except they assume that policies and programmes encouraging adoption of measures for reduction of GHG emissions or enhancing carbon sink could also be implemented.

The Interim Report had considered an overall alternative scenario considering the most ambitious levels of emission reduction possibilities in each sector to be able to conduct a first assessment of the range of possibilities and arrive at a sense of the likely range of possibilities for Malaysia. The BAU and this AMB scenario were discussed at the stakeholder consultation workshop following submission of the report. Based on the feedbacks and further inputs from the process of consultations, the draft final report develops and analyses alternative scenarios in each sector to examine the effect of specific policy and technology interventions, and/or be driven by specific constraints on absolute or cumulative emissions.

Following the evaluation and prioritization of the mitigation options across sectors, a combined AMB scenario, policies and measures that could encourage adoption of mitigation option(s) in each sector are suggested to layout the roadmap towards achieving the mitigation target within the given timeframe.

Combining quantitative analysis with stakeholders discussions, a roadmap has been outlined that lays out the prioritized options in each of the sectors, along with suggestions on policy, regulatory and institutional measures and mechanisms to create an enabling environment for successful implementation of the roadmap.

The overall approach of the study applies for both energy and non-energy sectors. However, given that the energy sector is more complex, with implications of specific options on both the demand and supply sides and implications across sectors and resources, the MARKAL model was used to analyse the various options in the energy sector and evaluate the implications of scenarios specific to the energy sector. The MARKAL model allows analysis of options on the end-use side such as residential, commercial, industrial, agriculture, and transport sectors. The supply-side focuses on options in electric power generation, oil and gas, coal, and other renewable resources. The integrated energy sector model captures demand and supply side inter-linkages. In case of non-energy sectors, bottom-up analytical methods are used to estimate carbon and other GHG flows.

Stakeholder consultations (including policy makers, industry groups, and sector experts) have been an overarching element of this study, along with focused group discussions and one-to-one interviews to understand the country's policy environment, gauge the likelihood of technological progress in each sector, and assess the availability of resources in the future. The stakeholder discussions have contributed to the understanding of technological options in terms of the techno-economic status and potential at the national level, and information regarding the availability and diffusion of alternative options over time. Inputs regarding barriers to the use of alternative fuels and technologies from the viewpoint of different stakeholders brings in an appreciation of the existing limitations due to various reasons such as consumer choices, affordability concerns, religion, culture, etc., thereby helping both in the formulation of appropriate boundaries or constraints and in suggesting changes in policies and institutions.

The output of the mitigation study includes the following:

- i. Trending of energy utilisation, primary energy supply, fuel mix and sectoral energy consumption patterns of the country.
- ii. Findings on GHG emission issues in Malaysia covering historical trends on the availability of fossil fuels (indigenous sources and imports) and renewable resources.
- iii. Indication of future emissions, policies and programmes that need to be considered especially from the energy and non-energy sectors comprising waste, LULUCF, agriculture and industrial processes to address the adverse impact of GHG emission on climate change.
- iv. Indicative scenario analysis that will examine the implications, likely cost and benefits as well as barriers to alternative pathways for the country towards meeting the intended carbon reduction.
- v. Potential technological options and innovative solutions that can be adopted across the economy to achieve the carbon emission intensity target.
- vi. Recommendation on mitigation policies, programmes and practical initiatives to achieve the target emission intensity reduction covering the Energy Sector, Waste Sector, Land Use, Land Use Change and Forestry (LULUCF), Agriculture and Industrial Processes.
- vii. Recommendation on technological options to achieve a low carbon economy up to and beyond 2020.

3.2 Outline of Mitigation Analysis

This report seeks to examine the transitions in activity levels and the resultant implications on emissions in the Malaysian economy as a whole and for each of the sectors in particular. This would help delineate where the country is heading in a Business-As-Usual (BAU) scenario. This is one of the most crucial steps in examining the potential for moving away towards alternative options since it provides a broad understanding of existing patterns of production, consumption and development, status of policies and plans in the country, and level of technology diffusion in the economy across various sectors.

This report brings together the data and information collected in each of the sectors and based on analysis of the data lays out the Business-as-usual trajectory for the country. Based on the understanding of the potential options, status of policies and plans, development priorities, etc., this report also presents ambitious scenarios across each of the sectors to enable an assessment of the mitigation potential compared to the BAU scenario. The report also discusses the roadmap for Malaysia in going along with the options proposed in the Ambitious scenarios based on an overall Ambitious scenario for the economy.

The structure of this Mitigation report will be reported as follows:

Section 3.3 deals with waste generation and its management.

Section 3.4 describes the forestry, and LULUCF sectors.

Section 3.5 focuses on the agriculture sector

Section 3.6 provides a broad overview of energy demand in the country and its distribution across the various consuming sectors.

Section 3.7-3.9 provide details of the end-use energy sectors in Malaysia in terms of the growth trends, energy use patterns, assessment of state of technology and fuel use in each sector, review of policies and plans in Malaysia, and where possible and likely projections until 2030 of each activity levels. These include the transport, industrial, residential & commercial sectors.

Section 3.10 provides the energy supply overview of Malaysia. It examines trends of the energy fuel mix, an analysis of supply side technologies, and the associated emissions.

Section 3.11 provides the MARKAL model analysis and results.

Section 3.12 describes the “Others” sector which encompasses emissions not captured by the sectors described in the previous sections.

Section 3.13 provides an estimate of the aggregate emissions by 2020 and beyond in the BAU and an AMB scenarios. It also discusses the overall roadmap for the Malaysian economy based on the prioritization of the various options to arrive at a GHG emissions intensity reduction of up to 40% of 2005 level by 2020 while keeping in mind development concerns of the economy.

3.3 Waste Sector

3.3.1 Introduction

With Malaysia moving on the path of rapid development, a major increase in the generation of waste is also being experienced. This growth in waste generation also includes rapid increase in the quantities of domestic and industrial wastewater and sewage sludge. A major concern with this increased waste generation is that of the GHG emissions due to methane formation. This is largely a result of uncontrolled emission from land disposed solid waste, though generation of methane from wastewater and sewage sludge is adding up to the national concerns too.

Solid waste generation in Malaysia has seen a consistent increase over the past 3 decades as a result of rapid growth and urbanization that the country has witnessed since the mid-1980s. Increasing waste management costs have strained the budgets of the local authorities in Malaysia, with about 60% of their annual budget being spent on waste management services (Bernama, 2006)⁴ and securing final disposal landfills has also become one of the most serious social issues in Malaysia (JICA 2006)⁵.

Recognising the need to address issues in the waste sector, the Government has been proactive in laying out plans and policies for this sector and identifying it as a priority area for Malaysia. The National Strategic Plan (NSP) for solid waste management formulated in 2005 has set targets for increasing the recycling rate from 5% to 22% by 2020, and recovery of 25% methane generated from landfills by installing proper methane capture infrastructure. In addition, the government of Malaysia gazetted the Solid Waste and Public Cleansing Management Act (Act 672) on 30th August 2007, and it came into force on 1st September 2011. The Act aimed to provide for and regulate the management of controlled solid waste and public cleansing for the purpose of maintaining proper sanitation⁶. In continuation to the Act's enforcement, the Government of Malaysia identified the following strategies for handling solid waste:

- i. Immediate Safe closure of 16 non-sanitary landfills that are in sensitive areas
- ii. Upgrading of non-sanitary landfills
- iii. Building new sanitary landfills
- iv. Incinerators

⁴ Chandravathani, S., "Waste Reduction: No Longer An Option But A Necessity" Bernama Feb 9, 2006 viewed at http://www.bernama.com/bernama/v3/news_lite.php?id=179384 on December 01, 2011

⁵ The Study On National Waste Minimisation In Malaysia, prepared by Japan International Cooperation Agency (JICA) July 2006

⁶ Solid Waste and Public Cleansing Management Act 2007 Laws of Malaysia viewed at http://www.kpkt.gov.my/jpspn_en/main.php?Content=vertsections&SubVertSectionID=21&VertSectionID=20&CurLocation=20&IID=&Page=1 on December 9, 2011

Traditionally, waste used to be disposed in an unscientific manner in landfills, and no attempts were made to either find alternatives or resort to scientific landfilling practices such as provision of impervious bottom lining or landfill gas recovery. However, Malaysia has now identified strategies for waste management across the board. In particular for dealing with solid waste management in urban areas, the government recognizes the need for adopting the sanitary landfilling practice as against the baseline practice of disposing waste in open dumps. Table 3.3.1 provides a list of landfill sites in operation as of June 2012.

Table 3.3.1: Status of landfill sites in Malaysia as of June 2012⁷

State	Number of Operational Sites	Number of Closed Sites	Total
Johor	14	23	37
Kedah	8	7	15
Kelantan	13	6	19
Melaka	2	5	7
Negeri Sembilan	7	11	18
Pahang	16	16	32
Perak	17	12	29
Perlis	1	1	2
Pulau Pinang	2	1	3
Sabah	19	2	21
Sarawak	49	14	63
Selangor	8	14	22
Terengganu	8	12	20
WP Kuala Lumpur	0	7	7
WP Labuan	1	0	1
TOTAL	166	130	296

Since 2005, the focus of the local authorities has shifted towards improving waste management (collection, recovery and recycling) and disposal practices. Under the NSP 2005, efforts are now being made to move towards establishing sanitary land-filling (Table 3.3.2) to facilitate recovery of landfill gas thus reducing uncontrolled methane gas emissions.

⁷ National Solid Waste Management Department, June 2012

Table 3.3.2: State-wise distribution of operational sanitary and inert waste disposal sites as of December 2011⁸

State	Number of Sanitary Sites (Level 4) ⁹	Number of Inert Waste Sites
Johor	2	-
Pulau Pinang	-	1
Sarawak	3	-
Selangor	3	2
TOTAL	8	3

Source: National Solid Waste Management Department, 2011

As per the available information, landfill gas recovery projects registered under the Clean Development Mechanism (CDM), such as the Bukit Tagar landfill facility, have provision of around 50% recovery of landfill gas. It is estimated that this will be achieved at a cost of about RM 270 million (Kam, Rachael, 2010)¹⁰.

3.3.2 Waste Generation and Treatment Scenario in Malaysia

Kathiravale et al (2003)¹¹ has estimated the national average per capita waste generation to be around 0.9953 kg/capita/day. Another study estimates that per capita waste generation would increase from 1.40 kg/capita/day in 2025 to 1.59 kg/capita/day by 2035¹². The share of urban population has increased from 51.4% in 1980 to 63.5% in 2010, and expected to increase to around 70% by 2030. The waste generation rate for urban population, as per the NSP 2005 is reported at 0.9 kg/capita/day. Accordingly, future waste generation projections (Table 3.3.3) for urban population are estimated at 0.9 kg/day/capita. Based on these assumptions, solid waste generation for urban population in Malaysia is estimated to be 18,228 tonnes per day by 2020, and 22,317 tonnes per day by 2030 as indicated in Table 3.3.3.

⁸ National Solid Waste Management Department 'The Number of Disposal Site/Operational Level/Collection Average' viewed at http://www.kpkt.gov.my/jpspn_en/main.php?Content=sections&SectionID=24&IID=

⁹ Level 4 landfills refer to scientific sanitary landfills with bottom liners and provision for leachate collection and treatment and landfill gas collection

¹⁰ Kam, Rachael, "More landfills next year", The Star Malaysia July 15, 2010 viewed at <http://thestar.com.my/news/story.asp?file=/2010/7/15/nation/6669196&sec=nation> on December 9, 2011

¹¹ S. Kathiravale et al "Energy potential from municipal waste in Malaysia" Journal of Renewal Energy, 2003

¹² http://enviroscope.iges.or.jp/modules/envirolib/upload/1565/attach/08_chapter6.pdf

Table 3.3.3: Projected urban solid waste generation in Malaysia

Year	Solid Waste Generation (Tonnes per day)
2010*	16,904
2015	17,097
2020	18,228
2025	20,169
2030	22,317

Notes: *based on MHLG data of 26,620 tonnes per day and urban population rate of 63.5% for 2010. Projected values are based on generation rate of 0.9 kg/capita/day and urban population as given in Appendix 3.3.

Source: TERI estimates adapted from NSP 2005

Solid waste in Malaysia has a high organic content comprising of mostly food waste (Table 3.3.4).

Table 3.3.4: Composition of solid waste in Malaysia for 2005¹³

Component	Percentage
Food waste	45
Plastic	24
Paper	7
Steel	6
Glass	3
Others	15
Total	100

Source: National Solid Waste Management Department, 2011

Given the large and growing quantity of solid waste generation, and the current practices of disposal as adopted in Malaysia, one of the most pressing issues is limited land availability for waste disposal in the country. The constraint of land has in fact been the primary driver for motivating the introduction of policies related to waste treatment and management. Methods adopted for dealing with increased waste generation will have a key role to play in Malaysia, as this will have a direct impact on the future possibility of exploiting landfill gas generation. For instance, if more waste is diverted from landfill, lesser would be landfill gas generation in future.

Methane recovery from landfills is an option for reducing GHG emissions arising from decomposition of waste. Further, the development of a Material Cycle Recovery Society has also been envisaged, with emphasis on achieving increasing waste recycling. In addition to this, options such as waste incineration and conversion to refuse derived fuel (RDF) are also being explored for major urban centres like Kuala Lumpur for tackling the increasing solid waste generation.

¹³ National Solid Waste Management Department, Ministry of Housing and Local Government, Malaysia viewed at http://www.kpkt.gov.my/jpspn_en/main.php?Content=articles&ArticleID=48&IID= on December 1, 2011

3.3.2.1 Recycling and Material Recovery Facility

Solid waste in Malaysia (Table 3.3.4) has a significant amount of recyclable waste such as plastic, paper and steel wastes. The aim of the NSP is to create a Material Cycle Recovery Society that actively encourages segregation and recycling of waste. As of now, a recycling rate of 5% has been achieved, and a target recycling rate of 22% by 2020 has been set by the government of Malaysia¹⁴. GHG emissions can be reduced should recycling and recovery be aggressively promoted as the plastic, paper and metal wastes can be effectively recycled thereby reducing the need for raw material.

3.3.2.2 Composting

Composting of the organic wastes is a waste processing option that can be practiced in tandem with recycling and material recovery for addressing the problem of biodegradable waste. This is suitable considering the fact that solid waste in Malaysia has a very high organic component (food waste). The two methods of composting – aerobic and anaerobic composting – both offer their unique advantages. While aerobic composting converts waste into CO₂ as against emission of CH₄, the anaerobic composting converts waste into CH₄ rich biogas and manure. The biogas can be used either for thermal or power applications. Waste to energy is identified as the primary waste management option under the NSP 2005.

3.3.2.3 Incineration and Refuse Derived Fuel (RDF)

As of 2008, about 4% of the waste was subjected to incineration and conversion to RDF¹⁵. Across the country, a target incineration rate of about 175 tonnes per day of wastes has been put forward as shown in Table 3.3.5. The same shall be targeted through the introduction of four incinerators, of which one at Pulau Pangkor is now functional, while the other three are near to completion, pending at various stages (two shall start operating by the end of 2012 while the last one is in building works completion stage). The commercial resource recovery facility and waste-to-energy facility launched in Selangor, Malaysia, can handle up to 700 tonnes per day of waste. Ramaswamy (2008) has estimated that the plant currently running at - Kajang Technical Park handles roughly about 46,200 tonnes of waste in the year - to achieve - a net emission reduction of 0.12 MtCO₂ eq. per year¹⁶.

¹⁴ It considers increase in 2-3% recycling on an annual basis. This however does not include informal recycling presently happening, the actual figures of recycling will have to be adjusted against informal recycling.

¹⁵ Adopting Kyoto Protocol: Clean Development Mechanism (CDM) Approaches For Solid Waste Treatment Experience By RRC/WTE Facility presented at EU-Asia Solid Waste Management Conference October 29, 2008 viewed at <http://www.ea-swmc.org/download/postconf/Puvaneswari%20Ramasamy.pdf> on December 9, 2011

¹⁶ Adopting Kyoto Protocol: Clean Development Mechanism (CDM) Approaches For Solid Waste Treatment Experience By RRC/WTE Facility presented at EU-Asia Solid Waste Management Conference October 29, 2008 viewed at <http://www.ea-swmc.org/download/postconf/Puvaneswari%20Ramasamy.pdf> on December 9, 2011

Table 3.3.5: Mini-incinerators built under 9th Malaysia Plan¹⁷

Location	Capacity (Tonnes per day)
Pulau Pangkor, Perak	20
Pulau Langkawi, Kedah	100
Pulau Tioman, Pahang	15
Cameron Highlands, Pahang	40

Note: These are mini-incinerators of typically 20-100 tons per day capacity which are indigenously developed.
Source: National Solid Waste Management Department, 2011

Incineration with the option of energy recovery involves direct energy generation that can be fed to the grid. It also achieves reduction in waste quantity entering the landfills, thus reducing the requirement of much land for disposal. A major disadvantage however tends to be the potential pollutants arising from it, especially carcinogenic dioxins. Nonetheless, if properly managed, they can be reduced effectively.

Another alternative to address the problem of incineration is producing RDF from the solid waste. As of 2011, about 700 tonnes per day (TPD) waste is sent to the RDF site at Semenyih in Selangor state¹⁸, where it is processed to generate the alternate fuel. This fuel is then sold to industries to meet their energy demands. While recycling offers distinct advantage over converting the solid waste to RDF especially in the case of waste paper and plastics, not all waste paper and plastics are salvageable for material recovery and combined with materials like rags, leather, hard wood, etc. can be gainfully converted to RDF.

3.3.2.4 Wastewater Generation in Malaysia

With rapidly increasing urbanization trends in Malaysia, there are growing concerns regarding methane generation from municipal wastewater. As per the Indah Water Konsortium (IWK, 2011)¹⁹, 6,313 sewage treatment plants (STPs) were maintained by IWK. Apart from these STPs, Malaysia extensively uses primary treatment systems such as

¹⁷ S. Kathiravale et al "Energy potential from municipal waste in Malaysia" Journal of Renewal Energy, 2003

¹⁸ National Solid Waste Management Department 'The Number of Disposal Site/Operational Level/Collection Average' viewed at http://www.kpkt.gov.my/jpspn_en/main.php?Content=sections&SectionID=24&IID=

¹⁹ Facts About Sewage Treatment Plants, Indah Water Konsortium (IWK) viewed at <http://www.iwk.my/f-sewer-age-fact.htm> on December 9, 2011

communal septic tanks and Imhoff tanks and low cost secondary treatment systems such as oxidation ponds. In addition, large urban areas utilize Individual Septic Tanks (IST)²⁰. It is estimated that there are over one million ISTs in Malaysia. As of 2010, around RM 5,072 million has been invested in providing sewage management services (IWK, 2010). The water consumption has risen from 0.52 million m³ in 2007 to 0.72 million m³ in 2010. Considering that 80% of water use would eventually end up as sewage, the present sewage generation is estimated at 0.58 million m³. This would be equivalent to emission of 0.42 MtCO₂ eq. for year 2010 (IWK, 2012). Further, as technology options like septic tanks lead to the formation of methane gas that cannot be tapped, efforts are being made to find alternatives. Untreated wastewater sludge leads to generation of methane rich biogas which is source of GHG.

On the industrial side, wastewater from palm oil mills currently contributes 93.3% of methane emission while 3.8% is contributed by rubber industries. Further, the Palm Oil Industry is expected to continue playing a dominant role within the agro-industrial group of Malaysia, with the Sarawak state government recently announcing the opening up of large tracts of land for oil palm cultivation (Teoh, 2010)²¹. This is because Malaysia has reported a steady decline in rubber acreage, which had fell from the peak of 1.89 million hectares in 1978 to 1.25 million in 2003 (1.4 million in 2004). The decline in Natural Rubber planted area for many producing countries is attributable to several reasons. In particular, some estates have converted to more profitable commodities, such as oil palm²². As of March 2012, the Malaysian Palm Oil Board²³ states that there are about 422 fresh fruit bunch mills, 44 palm kernel crushers, 52 refineries and 17 Oleo-chemical units operating in Malaysia. Estimates of the quantity of effluent that is generated from the palm oil mills vary from 53 to 66.8 million m³ for year 2005 (Rupani et al, 2010)²⁴. Again for 2008, Wu et al (2010)²⁵ stated that in 2008 at least 44 million tonnes of Palm Oil Mill Effluent (POME) were generated in Malaysia, and that ponding system is the most common treatment method for POME but other processes such as aerobic and anaerobic digestion, physicochemical treatment and membrane filtration are also being considered.

In this study, we consider only the palm oil mill effluent for detailed analyses, as this is the major contributor of methane emissions as compared to other industrial sectors like latex and rubber based industries.

²⁰ Department of Statistics Malaysia, Malaysia Census 2010 viewed at http://www.statistics.gov.my/portal/index.php?option=com_content&view=article&id=1215%3Apopulation-distribution-and-basic-demographic-characteristic-report-population-and-housing-census-malaysia-2010-updated-2972011&catid=130%3Apopulation-distribution-and-basic-demographic-characteristic-report-population-and-housing-census-malaysia-2010&lang=en

²¹ Teoh, Cheng Hai, Key Sustainability Issues in the Palm Oil Sector: A Discussion Paper for Multi-Stakeholders Consultations commissioned by the World Bank Group, April 2010

²² <http://r0.unctad.org/infocomm/anglais/rubber/crop.htm>

²³ Number and Capacities of Palm Oil Sectors March 2012 (tonnes/year), Malaysian Palm oil Board viewed at <http://bepi.mpob.gov.my/index.php/statistics/sectoral-status/106-sectoral-status-2012/512-number-a-capacities-of-palm-oil-sectors-2012.html>

²⁴ Rupani, P.F., Singh, R.P., Ibrahim, M.H., and Esa, N., Review of Current Palm Oil Mill Effluent (POME) Treatment Methods: Vermicomposting as a Sustainable Practice, World Applied Sciences Journal 11 (1): 70-81, 2010

²⁵ Wu, T.Y., Mohammed, A.W., Jahim, J.M., and Anuar, N., Pollution control technologies for the treatment of palm oil mill effluent (POME) through end-of-pipe processes, Journal of Environmental Management 91 (2010) 1467-1490

3.3.3 Current Policy Scenario

Traditionally, waste collection and disposal in Malaysia is the prerogative of the Local Authority (LA). While laws dating as far back as 1974 are in place, the solid waste scenario saw a real spurt in activity in 1994, when private players were invited to participate. In parallel, the government has brought in policies and legislations to deal with the emerging scenarios. Responding to emerging solid waste issues, the government of Malaysia has included waste management issues in its National Plan. The 8th Malaysian Plan (2001 – 2005) had included waste minimization, promotion of reuse and developing recycling-oriented society as part of its plans. The 9th Malaysia plan (2006-2010) further emphasized on the continuation of 3R efforts. Allocation for research and development of technology on reuse of waste was also included. The 10th Malaysia plan (2011 – 2015) re-emphasizes on the need to federalize solid waste management, privatization of solid waste collection and disposal and upgrading or closure of current landfill sites. A list of the legislative and policy measures that have been introduced and enforced in Malaysia is provided in Table 3.3.6.

Table 3.3.6: Key acts and policies related to solid waste management

Act /policy	Vision/Objectives
Action plan for a beautiful and clean Malaysia (ABC) 1988	Proposed the formulation of a "National Solid Waste Management Policy" and the establishment of a municipal solid waste management system to cover whole of Malaysia by 2010. Specific focus was to find means that are uniform, cost effective, environmentally sound and socially acceptable.
The National Policy on the Environment 2002	A major objective of the policy is to ensure sustainable lifestyles and patterns of consumption and production, with specific focus towards goals for continuous economic, social and cultural progress of Malaysia and enhancement of the quality of life while accounting for environmentally sound and sustainable development.
National Strategic Plan for Solid Waste Management in Malaysia, NSP 2005	Provides a strategic framework related to the overall management of solid waste in Malaysia including the scope of privatization and implementation strategies, taking into account current obstacles or shortfalls faced in implementing the privatization policy; and Recommends a management plan, which identifies the roles of each of the stakeholders, and actions that are required to be taken to meet the objectives of National Development Policy.
Master Plan on National Waste Minimization, 2006	To provide vision, strategies, and role of stakeholders to minimize MSW generation.

table continues...

Act /policy	Vision/Objectives
National Committee on Solid Waste Management and Environment , 2006**	Committee chaired by Deputy Prime Minister which coordinates with State Governments and related Federal agencies on matters pertaining to solid waste management.
Solid Waste and Public Cleansing Management, SWPCM Act 2007 (Act 672)	An Act to provide for and regulate the management of controlled solid waste and public cleansing for the purpose of maintaining proper sanitation.
Solid Waste and Public Cleansing Management Corporation, SWPCM Corporation Act 2007 (Act 673)	An act to provide for the establishment of the solid waste and public cleansing management corporation with powers to administer and enforce the solid waste and public cleansing management laws and other related matters.
National Policy on Climate Change (2009)	Incorporation of measures including mobilizing financing and technical assistance in many areas including waste management and integration of measures into policies, plans, programmes and projects in areas that include the waste management.

** This committee has been abolished since end of 2011. All matters related to coordination with the State Governments and related Federal agencies are brought to the attention of National Local Government Council chaired by the Deputy Prime Minister.

Formation of National Strategic Plan for Solid Waste Management 2005

The National Strategic Plan for Waste Management (NSP) was formulated and adopted by the Federal Government of Malaysia in July 2005. NSP 2005 aims to provide a strategic framework for the integrated approach to the management of solid waste and federalisation of solid waste management with six main strategies as tabulated in Table 3.3.7.

Table 3.3.7: Strategies in National Strategic Plan for Solid Waste Management 2005

No	Strategies	Objective	Current status
1	Determination of SWM priorities	Adopting the SWM hierarchy: Reduce, Reuse, Recover and disposal	Efforts to increase recycling rate up to 22% by 2020 are undertaken
2	Rapid and comprehensive development of the necessary legal and institutional framework	Identify and propose mechanism to incorporate federal, state and local authorities in SWM including infrastructure and financial arrangement	1. Act 672 formulated and enforced in 1st September 2011 2. Establishment of National Solid Waste Management Department in 2007 3. Establishment of Solid Waste and Public Cleansing Management Corporation in 2008
3	Development of public participation in SWM	Enhance involvement of public in SWM through recycling	Awareness campaigns carried out by the government, NGOs and other related parties from time to time.
4	Provision of sustainable technologies for SWM	Adopting sustainable approach in SW treatment and disposal	1. Construction of new sanitary landfills at 9 sites 2. Upgrading of non-sanitary landfills to sanitary level at 30 sites currently in progress 3. Safe-closure of 16 non sanitary landfills in progress 4. Four mini-incinerators built at islands and highland.
5	A comprehensive approach to develop the waste reduction, reuse and recovery elements of SWM	Promoting full participation of all main players	Development of Waste Minimisation Plan 2006
6	A socially acceptable SWM system that calls for substantial initial government intervention with gradual shift towards full cost recovery	A financial plan providing large capital investment in the short term to meet urgent requirements, without creating social inequalities and with progressive cost recovery by year 2020	Full privatisation of controlled solid wastes collection from households to three concession companies in September 2011 in tandem with enforcement of Act 672

Source: NSP 2005

A comprehensive Waste Minimisation Master Plan was published in 2006, under a project supported by Japanese International Corporation Agency (JICA) from July 2004 to June 2006. The study proposed an action plan for the Malaysian government and waste minimization guidelines for schools, local authorities and other stakeholders.

The study identifies the following major issues on waste minimisation efforts:

- i. Increase in waste generation and SWM cost
- ii. Lack of basic data on SWM and recycling
- iii. Lack of awareness on waste minimisation
- iv. Lack of policies to promote waste minimisation
- v. Limited information and linkage among the stakeholders

The proposed master plan strategies to overcome the identified challenges are listed in Table 3.3.8.

Table 3.3.8: Action plans as proposed in the masterplan on waste minimization 2006

Master plan strategies	Action plan	Approaches	Current status
Strategy 1 – Enhancement of awareness on waste minimisation	Action 1 – Enhancement of awareness raising activities under the national recycling programme	Involve all stakeholders in all settings - consumer's green purchasing awareness - green production practice in manufacturing industries - less packaging materials - involvement of NGO, residential association - awareness among LAs and government agencies - using mass media	Awareness campaigns carried out by government, NGOs and related parties from time to time. Introduction of 2+1 collection system at capital cities (at states where Act 672 is enforced) from September 2012
	Action 2 – 3R activities in schools		1. Recycling Bank programme carried out at 110 schools in the country. 2. 3R activities carried out at higher learning institutions from time to time.

table continues...

Master plan strategies	Action plan	Approaches	Current status
Strategy 2 – Strengthening of 3R activities	Action 3 – Formulation of stakeholders networking and development of partnership activities on 3Rs	Connecting the consumers, collectors, buyers and government agency through - partnership with relevant NGOs/residential associations - partnership within the recycling industry - inter-ministerial partnership (promoting 3Rs among ministries) - inter local authorities partnership - partnership within business entities	1. 3R activities in partnership with NGOs and related parties
	Action 4 – Strengthening legal, regulatory and financial framework	1. Establishment of the legal and regulatory framework 2. Strengthening the financial and economic incentives 3. Capacity development of the government sector	SWPCM Corporation Act 2007 gazetted and enforced in September 2011
Strategy 3 – Enhancement of institution to strengthen government policies on waste minimisation Master plan strategies	Action 5 – Improvement of information management	Establishment, monitoring and implementation of information management system (IMS)	Plans to develop a National Waste Data Centre
	Action 6 – Provision of guidance to LAs WM-M/P		Publication of guidelines: 1. Guidelines for enhancement of 3Rs Activities in schools 2. Guidelines for Formulation of local action plan on waste minimisation 3. Guidelines for source separation of MSW 4. 3Rs Action guide

Source: Master Plan on National Waste Minimisation, 2006

The master plan on waste minimisation report is a very comprehensive document which provided detailed action plan for local authorities, NGOs and Ministries to promote and implement waste minimisation programme at source. Pilot recycling programmes which run between June and December 2009 (MHLG, 2010) showed that 91% to 92.6% of the collected recycled materials were papers. The percentage of plastic ranged from 3.4% to 4%, while metal ranged from 3% to 3.97%.

Solid Wastes and Public Cleansing Management Act 2007 (SWPCM Act)

Consequent to the NSP 2005, the Malaysian Parliament passed the Solid Wastes and Public Cleansing Management Act (SWPCM Act) in July 2007, which is applicable to Peninsular Malaysia, Federal Territory of Putrajaya and Labuan, and was enforced in September 2011. The Act allows the Federal Government to have executive authority with respect to all matters relating to the management of solid waste and public cleansing throughout Peninsular Malaysia and the Federal Territories of Putrajaya and Labuan. National Solid Waste Management Department under the Ministry of Housing and Local Government is entrusted with the responsibilities of formulating policies, strategies, action plans and regulations and agreements to implement SWPCM Act 2007. The Government also passed the Solid Waste Management and Public Cleansing Corporation Act in 2007 with the establishment of National Solid Waste Management Corporation. The Corporation is established to administer and enforce the solid waste and public cleansing management laws and for related matters.

Under Act 672, controlled solid wastes are defined as any solid waste falling within any of the following categories:

- i. Commercial solid waste;
- ii. Construction solid waste;
- iii. Household solid waste;
- iv. Industrial solid waste;
- v. Institutional solid waste;
- vi. Imported solid waste;
- vii. Public solid waste; or
- viii. Solid waste which may be prescribed from time to time

Lack of trained personnel having expertise in this area is proving to be a major impediment in Malaysia along with the absence of proper infrastructure (Manaf, Samah and Zukki, 2009). Also, awareness about the provisions of the Acts is disseminating at a slow pace.

National Policy on Climate Change 2009

On 20 November 2009, Malaysian Ministerial council passed the "National Policy on Climate Change" that provided a framework to mobilize and guide all stakeholders including government agencies in addressing the challenges of climate change holistically and through collaborative participation. The aim of policy is to ensure the achievement

of climate-resilient development in order to fulfil the national aspiration for sustainability. It recognizes the threat of climate change and addressing the threat via adaptation and mitigation. It includes climate change considerations into planning and implementation of development programmes. One of the key actions is to incorporate measures to mobilize financing and technical assistance and integrating policies, plans, programmes and projects into waste management area. The National Policy on Climate Change intends to adopt a systematic and targeted formal and informal education system and to focus on enhancing awareness on climate change through involvement of various stakeholders including NGOs, community based organization (CBOs) and the media. The awareness raising can be enhanced through cooperation between government sector and private sector including corporate responsibility. Promoting sustainable lifestyles and exploring possible incentives to promote it are also important.

3.3.4 Emissions Attributed to the Waste Sector

3.3.4.1 Solid Waste

The baseline scenario for solid waste management considers the business as usual practice of dumping waste in landfills without any recovery, recycling or landfill gas recovery (consistent with the existing scenario identified under the NSP 2005). For achieving GHG emission reduction, combination of waste management strategies are identified, which include material recovery, composting, combustion of refuse derived fuel, and landfill gas recovery.

Using the IPCC 1996 guidelines for calculating methane emissions from solid waste, and assuming that the entire waste is going to the sanitary landfills, by year 2030, the landfills would generate about 33.87 MtCO₂ eq. (Table 3.3.9). Table 3.3.9 also provides estimates for emission reduction in cases of 5%, 22% and 40% recycling of waste.

Table 3.3.9: Potential methane emissions from recyclable solid waste under different scenarios

Year	Methane Emissions (MtCO ₂ eq.)			
	with 0% recycling of waste	with 5% recycling of waste	with 22% recycling of waste	with 40% recycling of waste
2010	25.65	25.18	23.57	21.86
2015	25.95	25.47	23.84	22.11
2020	27.66	27.15	25.41	23.57
2025	30.61	30.04	28.12	26.08
2030	33.87	33.24	31.11	28.86

Notes: The percentage of recyclable material present in the municipal solid waste is taken as 37% (NSP 2005). The fraction of urban municipal solid waste dispose to landfill is 100%. The degradable organic carbon (DOC) is assumed to be 0.55 (NC2, 2012) and faction of DOC dissimilated, DOC_f = 0.9. Other factors are as listed in IPCC guidelines.

Source: TERI Estimates adapted from NSP 2005

Thus, overall emissions reduction of 5.01 MtCO₂ eq. can be achieved by 2030 if the recycling rates is enhanced to 40% as against 5% (present) and 22% (by 2020) as envisaged in NSP, 2005.

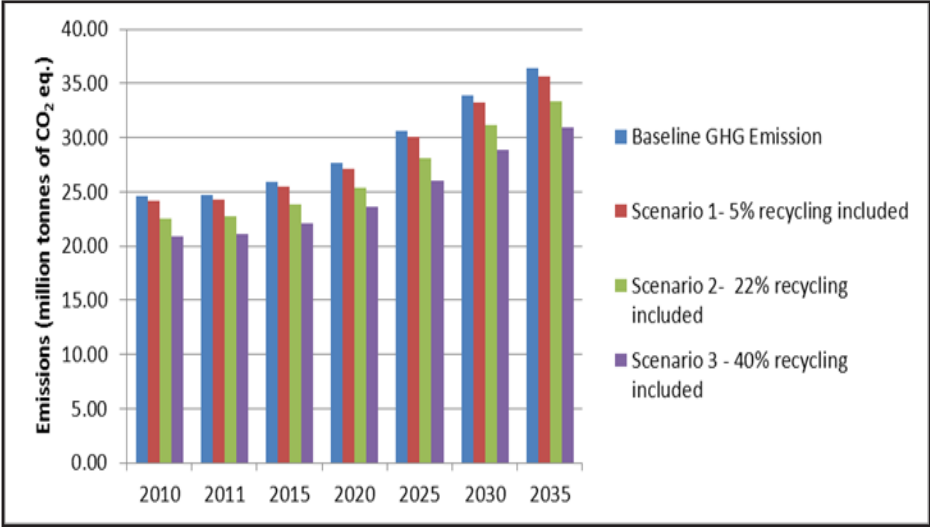


Figure 3.3.1: Reduction in emission achieved from waste recycling

Source: TERI Analysis, 2012

The importance of implementing a good waste segregation and recycling system which not only recovers resources but also results in lesser cost on overall waste management is exemplified in the three case studies presented in Box 3.1, 3.2 and 3.3.

Box 3.1: Case Study 1– Wongpanit Waste Bank, Thailand

Wongpanit is a highly successful waste collection and recycling company that has come up as per a concept introduced by Dr Somthai. Under the franchise model of collection, waste banks are owned and operated by micro entrepreneurs under franchise from Wongpanit, and this has contributed to the 22% recycling rate in Thailand. As well as serving domestic needs, processed and recycled materials are also sent abroad. Wongpanit, which has its own processing plants, exports 40% of what it processes to many countries, including Indonesia, Taiwan, Japan and Australia, and most of what it exports is aluminum. This is now being supported by efforts at policy making levels to shift focus on recycling, working with co-operatives and private companies, and local governments across the country have launched campaigns to increase public awareness of recycling.*

**Source: Busaba Sivasomboon, 'Enterprising collectors find trash means cash', Bangkok Post, April 15, 2012, [http://www.bangkokpost.com/print/288912/Ad conihil](http://www.bangkokpost.com/print/288912/Ad+conihil)*

Box 3.2: Case Study 2–Waste Categorization and Segregation for its Elimination by Kamikatsu, Japan

Kamikatsu city in Japan has raised the number of categories of waste from 34 to 44 in 2001, and aimed to eliminate waste completely by 2020. This enabled them to recycle high volumes of waste (about 80% in 2005) and reduce the amount entering landfills and incinerators. Moreover, community involvement by engaging people in the monitoring of waste disposal practices of the local people has contributed greatly towards nudging people into segregating waste at source.

Source: Norimitsu Onishi, 'How Do Japanese Dump Trash? Let Us Count the Myriad Ways' New York Times May 12, 2005, http://www.nytimes.com/2005/05/12/international/asia/12garbage.html?_r=1&pagewa...

Box 3.3: Case Study 3- South Korea's Recycling Laws

In order to improve the overall quality of the environment in the country, the South Korean Government implemented the volume-based waste fee system in 1995. The system requires every household to purchase specially designed plastic bags for waste disposal while the disposal of recyclables is free of charge. This was intended to discourage waste generation and maximize waste recycling. The idea has been quite successful, as data from the country's Ministry of Environment shows that the amount of waste produced per person was reduced 26 % from 1.33 kg per day in 1994 (the year before the system came into effect) to 0.99 kg per day in 2006. The recycling amount also significantly increased by 213% to 27, 900 tons per day from 8,927 tons per day.

Source: 'Recycling and waste-to-energy in S. Korea', Xinhua News Agency, August 19, 2011, http://news.xinhuanet.com/english2010/indepth/2011-08/19/c_131060871.htm

Landfill gas (LFG) recovery has been identified as an important measure for GHG emission reduction. Considering the fact that the Bukit Tagar landfill recovers and flares 50% of the total landfill gas²⁶, the corresponding net emissions for the various scenarios for landfills in Malaysia are shown in Table 3.3.10. This can also act as an incentive for the private sector involvement as desired by the government, and as identified under the NSP 2005. The private sector can invest in infrastructure for landfill gas capture and offset the cost by partly availing the CDM benefits and partly by possible sale/exploitation of landfill gas.

Table 3.3.10: Potential methane emissions post-flaring of LFG and recycling

Year	Methane Emissions (MtCO ₂ eq.)	After flaring & 5% recycling (Scenario 1)	After flaring & 22% recycling (Scenario 2)	After flaring & 40% recycling (Scenario 3)
2010	25.65	12.59	11.78	10.93
2015	25.95	12.73	11.92	11.05
2020	27.66	13.58	12.71	11.78
2025	30.61	15.02	14.06	13.04
2030	33.87	16.62	15.56	14.43

Note: Flaring here means 50% capture of generated LFG and flaring

Source: TERI estimates adapted from National Solid Waste Management Department, National Census 2010 and the Bukit Tagar landfill gas recovery CDM project

Thus the net emission reduction for 50% LFG capture and flaring and 40% recycling by 2030 would be 19.44 MtCO₂ eq. (57% over the baseline emissions in 2030).

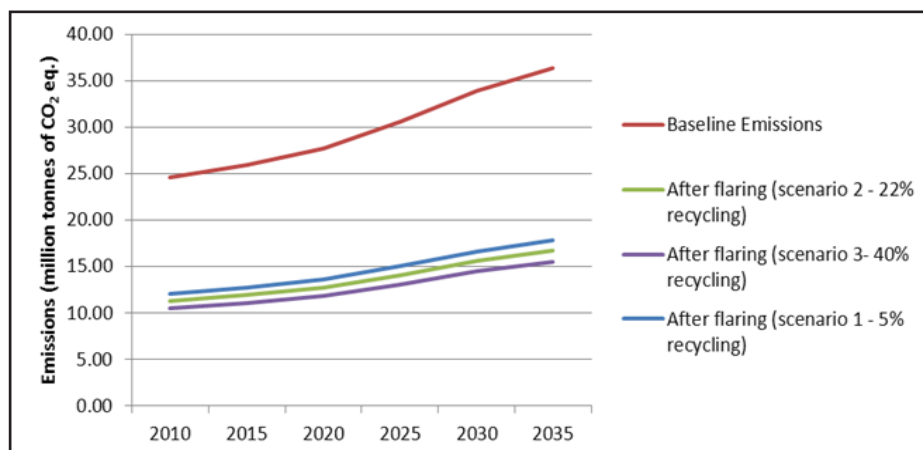


Figure 3.3.2: Reduction in emission at 50% LFG flaring and different stages of waste recycling

Source: TERI analysis, 2012

²⁶ CDM-Project Design Document for the Bukit Tagar Landfill Gas recovery Project viewed at http://cdm.unfccc.int/filestorage/B/Q/9/BQ9Y3FCZXL8HMNGA02IJ7DKWRT164S/2467_PDD_Rev_Clean.pdf?t=cHp8bHZ4bzUyfDAGtj5xBacluXnlPyw7JwOm on December 9, 2011

Further emissions can be avoided by adopting RDF route as discussed earlier. The emission avoided has been estimated for 4% based on current levels and 8% waste based on a doubling of this level converted to RDF (Table 3.3.11).

Table 3.3.11: Projected emissions avoided through RDF route

Year	Emissions avoided (MtCO ₂ eq.)	
	(4% waste recovered and used as RDF)	(8% waste recovered and used as RDF)
2010	0.64	1.28
2015	0.65	1.53
2020	0.69	1.83
2025	0.77	2.18
2030	0.85	2.60

Source: TERI Estimates Adapted from

<http://www.ea-swmc.org/download/postconf/Puvaneswari%20Ramasamy.pdf>

As can be seen in Table 3.3.11, a reduction to about 2.60 MtCO₂ eq. can be achieved with the doubling of the amount of waste sent across for RDF.

3.3.4.2 Domestic and Commercial Wastewater

Degradable Organic Carbon (DOC) in wastewater in Malaysia is high on a per capita basis with a national average of about 9125 kg Biochemical Oxygen Demand (BOD)/1,000 persons/year (IWK, 2012). In addition, as per IWK, about 0.05% of DOC gets removed as sludge. The entire quantity of domestic wastewater generated is treated by adopting a combination of primary treatment methods especially septic tanks and STPs.

Anaerobic digestors recover the methane rich bio gas which can be used to generate energy. The experience of the palm oil industry shows that anaerobic digestion provides the fastest payback of investment because the treatment enables biogas recovery for heat generation (Wu et al, 2010)²⁷. The United Nations Development Programme in fact recognizes it as a useful source of decentralized energy. The CH₄ emission factor for wastewater is 0.01875 kg methane/kg BOD and for sludge is 0.01405 kg methane/kg BOD. It is also assumed that there is no recovery or destruction of methane emissions from wastewater and sludge treatment. These factors and equations are used to estimate the methane emissions in the future, depending on the estimated future urban population.

The methane emissions from domestic and commercial wastewater are comparably less than those from solid waste, as shown in Table 3.3.12. Also, treatment efficiency of the systems in used is high, with BOD removal at 86% and suspended solids removal at 83%. Hence, the level of emissions from waste water is quite low. GHG emissions could be reduced using two scenarios. We have considered 50% removal and 75% removal of BOD from the treated wastewater using anaerobic digestors (Table 3.3.12).

²⁷ Wu, T.Y., Mohammad, A.W., Jahim, J.M., and Anuar, N., "Pollution control technologies for the treatment of palm oil mill effluent (POME) through end-of-pipe processes",

Table 3.3.12: Projected GHG emissions from domestic and commercial wastewater

Year	GHG Emissions before treatment (MtCO ₂ eq.)	GHG Emissions after treatment (MtCO ₂ eq.) (baseline)	GHG Emissions after treatment (MtCO ₂ eq.)	
			achieving 50% reduction on baseline	achieving 75% reduction on baseline
2010	0.094	0.013	0.006	0.003
2015	0.107	0.015	0.008	0.004
2020	0.126	0.017	0.009	0.004
2025	0.143	0.021	0.010	0.005
2030	0.150	0.022	0.011	0.005

Source: TERI estimates adapted from IWK 2012

In the BAU scenario, emissions from domestic and commercial wastewater are only just 0.022 MtCO₂ eq. in 2030. With high removal efficiencies already being achieved, the level as well as scope for reduction of emissions in this sector is small.

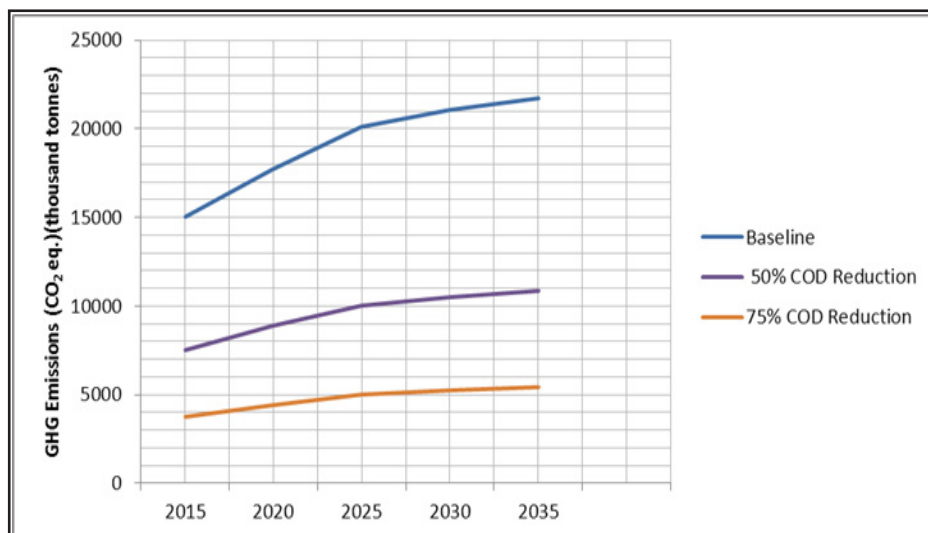


Figure 3.3.3: Emission reduction scenarios for commercial and domestic wastewater

Source: TERI Analysis, 2012

3.3.4.3 Industrial Wastewater Treatment

The production from the industrial units estimated for future years is estimated based on growth rate of production data from 2005-2010. On the basis of production, wastewater generation has been estimated and methane emissions are predicted, using 0.05625 kg of methane per kg COD as the emission factor. It has been reported that POME contributes to largest pollution load in the rivers, due to which the palm oil industry faces the challenge of balancing environmental protection with its own economic viability (Rupani et al 2010)²⁸.

As in the case of domestic and commercial wastewater, anaerobic digestors can be used to degrade the organic matter which is present in the industrial wastewater with 50% and 75% COD removal, and the results achieved are shown in Table 3.3.13.

Table 3.3.13: Projected GHG emissions from palm oil mill effluent (POME)

Year	GHG emissions (MtCO ₂ eq.)	GHG emissions (MtCO ₂ eq.)	
		with 50% COD removal	with 75% COD removal
2010	14.68	7.34	3.67
2015	16.65	8.33	4.16
2020	18.92	9.46	4.73
2025	21.18	10.59	5.30
2030	23.45	11.73	5.86

Notes: POME generation ratio is taken as 0.65 of FFB; biogas generation ratio is 28 m³/ tonne of POME
Source: TERI estimates adapted from Malaysian Palm Oil Board, 2012

Thus, emission level of 5.86 MtCO₂ eq. can be achieved over the baseline level of 23.45 MtCO₂ eq. for year 2030, with 75% COD removal. This equals to a reduction of 17.59 MtCO₂ eq.

3.3.4.4 Overall Emission Reduction

For the year 2020, based on our estimations, derived on data available across various subsectors, GHG emissions for BAU Scenarios are as follows; emissions from solid waste is at 27.66 MtCO₂ eq.; emissions from the palm oil industries is at 18.92 MtCO₂ eq; emissions from the domestic and commercial wastewater sector, with current level of treatment stands at 0.017 MtCO₂ eq. As a result, the total emissions in the BAU scenario, shall stands at 46.6 MtCO₂ eq. for the year 2020 (Table 3.3.14).

²⁸ Rupani, P.H., Singh, R.P., Ibrahim, M.H., and Esa, N., "Review of Current Palm Oil Mill Effluent (POME) Treatment Methods: Vermicomposting as a Sustainable Practice", World Applied Sciences Journal 11 (1): 70-81, 2010

Whereas, in year 2030, the GHG emissions for BAU Scenarios are as follows; emissions from solid waste is estimated at 33.87 MtCO₂ eq. ; emissions from the palm oil industries is at 23.45 MtCO₂ eq. ; emissions from the domestic and commercial wastewater sector, with current level of treatment stands at 0.022 MtCO₂ eq. Thus, the total emissions in the BAU scenario stands at 57.34 MtCO₂ eq. for the year 2030 (Table 3.3.14).

Considering all the proposed strategies of efficient management of solid waste that are in place, by 2020, it is possible to reduce 15.88 MtCO₂ eq. (57% reduction), bringing the emissions down to 11.78 MtCO₂ eq. (Table 3.3.10). It is also possible to reduce an additional 1.83 MtCO₂ eq. by converting waste to RDF and using it for energy recovery (Table 3.3.11). Within the palm oil mills, emissions can be reduced by an amount of 14.19 MtCO₂ eq. (75% reduction) to 4.73 MtCO₂ eq. (Table 3.3.13). A marginal reduction of 0.013 MtCO₂ eq. can be achieved in the domestic and commercial wastewater segment (Table 3.3.12). Thus, overall emissions from the waste sector can be brought down to 14.68 MtCO₂ eq. (Table 3.3.14).

Similarly, by 2030, it is possible to reduce 19.44 MtCO₂ eq. (57% reduction), bringing the emissions down to 14.43 MtCO₂ eq. (Table 3.3.10). It is also possible to reduce an additional 2.60 MtCO₂ eq. by converting waste to RDF and using it for energy recovery (Table 3.3.11). Within the Palm oil mills, emissions can be reduced by an amount of 17.59 MtCO₂ eq. (75% reduction) to 5.86 MtCO₂ eq. (Table 3.3.13). A marginal reduction of 0.017 MtCO₂ eq. can be achieved in the domestic and commercial wastewater segment (Table 3.3.12). Thus, overall emissions from the waste sector can be brought down to 17.7 MtCO₂ eq. (Table 3.3.14).

The overall GHG emission projections for year 2020 and 2030 as discussed above is presented as shown in Table 3.3.14.

Table 3.3.14: Overall projection of GHG emissions (MtCO₂ eq.) for waste sector

2005	2020		2030	
	BAU	AMB	BAU	AMB
27.4	46.60	14.68	57.34	17.70

Here, the BAU (business as usual) scenarios for 2020 and 2030 are assumed that no recycling and no LFG flaring for MSW; the domestic and commercial wastewater are treated at 86% efficiency and no treatment for POME. Whereas, the alternative scenarios are arrived at an assumption that 50% of LFG will be captured and flared and 40% of recycling rate for MSW. Around 8% of MSW will be converted to RDF and used as fuel. Domestic and commercial wastewater treatment will further achieve 75% COD removal over whatever is achieved in baseline condition and 75% removal of COD will be achieved for POME by anaerobic digestion process.

Possible cost for implementation of various waste management measures as per the requirements laid out in NSP 2005 is shown in Table 3.3.15.

Table 3.3.15: Possible costs for GHG mitigation in waste sector²⁹

Item	Projected Number of items as listed under NSP for 2020	Source
Sanitary landfill and gas flaring ³⁰	22	Average cost of sanitary landfill is RM 30 million. The total cost consists of capex and opex for sanitary landfills and collection cost. Source from Solid Waste Management Lab report, 2012
Recycling ³¹		Cost consists of bins, recycling centres and awareness campaign.
Incineration ³²	7	Costs consists of capex and opex of incinerators and collection .
Palm oil mill effluent managemet ³³	500 mills	Economic Transformation Program, Chapter 9 "Deepening Malaysia's oil palm advantage"

²⁹ Reference taken from NSP 2005

³⁰ Solid waste management lab, April 2012 Viewed at http://www.kpkt.gov.my/kpkt/fileupload/hebahan/lab_sisa_pepejal.pdf

³¹ ibid

³² ibid

³³ Economic Transformation Program, Chapter 9 "Deepening Malaysia's Palm Oil Advantage", EPP 5 – Developing biogas at palm oil mills". 2011

3.3.4.5 Action Plan for Implementation

As per the NC2 document for Malaysia, the waste sector accounts for 12% of total GHG emissions and is a key sector to influence any attempt to reduce GHG emission. The uncontrolled release of landfill gas from the waste disposal sites contributes to more than 90% emission of GHG in the waste sector. So, the key element of addressing reduction of GHG emission necessarily targets on capture of landfill gas and flaring it before releasing.

As per Malaysia's National Renewable Energy Policy and Action Plan (NREPAP) recognizes the ability of the solid waste sector to contribute about 378 MW of power by 2024 at 30,000 tonnes/day, and the contribution of POME along with other biomass components of the industry to contribute about 410 MW by 2028³⁴. The government has envisaged that about RM 20.1 billion can be raised by the end of 2030 to fund the renewable energy sector, to which these aspects are accounted for. In such a case, particular areas of work in policy which need to be stressed upon are:

- Cooperating with states to set up single stop approval centres, and work out with them on mechanisms to facilitate the functioning of the policy initiatives brought in³⁵.
- Introduction of fiscal incentives to encourage the participation of private sector could be another way to share the costs while also to create an atmosphere which is conducive for private sector participation as envisaged under NSP 2005.

Additionally, long term contracts can be signed with the private players to ensure their financial feasibility upon involvement in the management of solid waste in Malaysia. For example, municipal waste management in India is encouraged through various schemes such as interest subsidy and direct financial subsidy on the project under programmes such the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and the National Programme on Energy Recovery, which is extended to municipal wastewater treatment as well (EAI 2012)³⁶. Direct capital subsidy is similarly provided for industrial waste to energy projects, especially for waste to biogas, and these could be looked at too (EAI 2012)³⁷ for encouraging technologies in the palm oil mills.

Various actions to be implemented for achieving reduction can be categorised under short term (2013- 2015), medium term (2016 - 2020) and long term (beyond 2020) actions. These actions as discussed in previous sections are listed in Table 3.3.16.

³⁴ National Renewable Energy Policy and Action Plan (NREPAP), 2008

³⁵ National Renewable Energy Policy and Action Plan (NREPAP), 2008

³⁶ Energy Alternatives India viewed at http://www.eai.in/ref/ae/wte/pol/urban_waste_govt_support.html

³⁷ Energy Alternatives India viewed at http://www.eai.in/ref/ae/wte/pol/industrial_waste_govt_support.html

Table 3.3.16: Key measures to reduce GHG emission in waste sector

Short-term	Medium-term	Long-term	Remarks
Municipal solid waste			
Increasing the recycling rate to 10%	Increasing the recycling rate to 25%	Increasing the recycling rate to 40%	Recycling being operational issues linked to segregation of waste, change in mindset to achieve better segregation is expected to happen over time and aggressive awareness campaigns
Closing non-sanitary landfills with provision of LFG capture and flaring	Closing non-sanitary landfills with provision of LFG capture and flaring	Achieve capture of 50% landfill gas	Investment in landfill upgradation infrastructure, anaerobic digestion and incineration systems
Achieve capture of 10% landfill gas	Achieve capture of 25% landfill gas		Legal provision like landfill tax, incentive for decentralised/centralised organic waste treatment to divert waste from landfills
	Decentralised/ centralised development of anaerobic digestion/ incinerator system for treatment of food waste and capture of biogas		
	Move progressively towards diversion of organic waste from landfills		
Palm Oil Mill Effluent			
Reduction in organic load by 25% by adopting anaerobic digestion method	Reduction in organic load by 50% by adopting anaerobic digestion method	Reduction in organic load by 75% by adopting anaerobic digestion method	Regulation for zero discharge of organic load

To overcome the burden of finance in certain LFG projects, the proponents have applied for carbon finance under the Clean Development Mechanism (CDM) programme. Malaysia government had established green technology financing scheme to promote green technology which include harvesting biogas from landfills. Internationally, Green Climate Fund is also available for promoting cleaner low carbon growth across developing countries. Access to these could be availed for both solid waste management as well as palm oil mills for dealing with their effluent's methane emissions. Most projects in the palm oil sector could come under small scale projects, and hence would have easier clearance processes. Income from CDM benefits has already been exempted from tax under Income Tax Act 1967 (MEGTW, 2010)³⁸.

One of the Malaysia's Economic Transformation Plan initiatives is greater Kuala Lumpur Klang Valley initiative with the aim of improving sewerage infrastructure and services. One of the entry point projects is rehabilitating Klang River known as River of Life project. Since 2012, new sewerage treatment facilities had been designed and constructed, gross pollutants traps and grease traps had been installed. New sewage treatment plants had been installed at Selayang and Jalan Klang Lama wet market. The upgrading and building of sewage treatment plants will further reduce the potential emission reduction from domestic wastewater.

Another EPP is developing an efficient solid waste management system in Kuala Lumpur and greater Klang Valley. The four major initiatives are: encouraging greater implementation of the Reduce, Reuse, Recycle (3R) programme; Increasing waste treatment capacity to reduce reliance on landfills; Improving governance of solid waste management and public cleaning services; Assessing the potential of new technological developments such as automatic waste collection and the use of deep bins. The distribution of recycling bins of capacity 120-litres to households in Kuala Lumpur. Enhancement of recycling rate will be able to reduced the amount of waste disposed at landfill sites which will lead to reduced GHG emission from landfill sites . Jabatan Pengurusan Sisa Pepejal Negara JPSPN had identified site for future food waste recycling facility to cater for food waste from eateries from Klang Valley. JPSPN also had finalized procurement of equipments and machineries to upgrade the current site in Sg.Kertas to a construction and demolition waste facility. Another project is the construction of anaerobic digester which is at testing and commissioning stage. It is expected that these solid waste treatment facilities will be operational in 2013 and will support government GHG mitigation effort.

In terms of oil palm wastes, entry point project entitled "Developing biogas facilities at oil palm mills" was reported to have 57 biogas plants nation wide. 15 mills are currently developing their biogas facilities and 149 mills in their planning stage. One of the biogas facility at FELDA-owned biogas plant at Seriting Hilir, Negeri Sembilan was operating and connected to national grid. Another biogas plant is supplying electricity to a local village in Tawau. All these efforts will further reduce the GHG emission from oil palm mills.

³⁸ GREEN IMPACT: Low Carbon Green Growth, Ministry of Energy, Green Technology and Water, 2010

3.4 Land Use, Land-Use Change and Forestry Sector

Malaysia is among the most highly forested countries not only in South-east Asia, but also in the world. Accordingly, the LULUCF sector plays a key role in Malaysia's emission reduction roadmap, since forests are source as well as sink of carbon as indicated in Figure 3.4.1. In 2005, Malaysia was a net emitter with the LULUCF sector contributing 25.3 MtCO₂ eq. (MNRE, 2011).

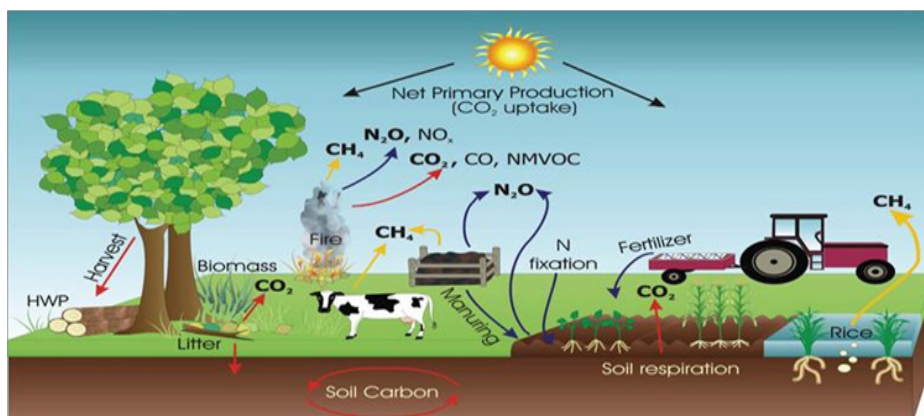


Figure 3.4.1: The main greenhouse gas emission sources/removals and processes in managed ecosystems

Source: IPCC Guidelines, 2006

The key greenhouse gases of concern are CO₂, N₂O and CH₄. CO₂ fluxes between the atmosphere and ecosystems are primarily controlled by uptake through plant photosynthesis and releases via respiration, decomposition and combustion of organic matter. N₂O is primarily emitted from ecosystems as a by-product of nitrification and denitrification, while CH₄ is emitted through methanogenesis under anaerobic conditions in soils and manure storage, through enteric fermentation, and during incomplete combustion while burning organic matter. Other gases of interest (from combustion and from soils) are NO_x, NH₃, NMVOC and CO, accounted as indirect emissions because they are precursors for the formation of greenhouse gases in the atmosphere. Indirect emissions are also associated with leaching or runoff of nitrogen compounds, particularly NO₃⁻ losses from soils, some of which can be subsequently converted to N₂O through de-nitrification.

Plant biomass, including above-ground and below-ground parts, is the main conduit for CO₂ removal from the atmosphere. Large amounts of CO₂ are transferred between the atmosphere and terrestrial ecosystems, primarily through photosynthesis and respiration. The uptake of CO₂ through photosynthesis is referred to as gross primary production (GPP). About half of the GPP is respired by plants, and returned to the atmosphere, with the remainder constituting net primary production (NPP), which is the total production of biomass and dead organic matter in a year. NPP minus losses from heterotrophic respiration (decomposition of organic matter in litter, dead wood and soils) is equal to the net carbon stock change in an ecosystem and, in the absence of disturbance losses, is referred to as net ecosystem production (NEP).

(Net Ecosystem Production (NEP) = Net Primary Production (NPP) – Heterotrophic respiration)

NEP minus additional C losses from disturbance (e.g., fire), harvesting and land clearing during land-use change, is often referred to as net biome production (NBP). The carbon stock change that is reported in national greenhouse gas inventories for land-use categories is equal to NBP.

(Net Biome Production (NBP) = NEP – Carbon Losses from Disturbance/ Land-Clearing / Harvest)

NPP is influenced by land use and management through a variety of anthropogenic actions such as deforestation, afforestation, fertilization, irrigation, harvest, and species choice. For example, tree harvesting reduces biomass stocks on the land. However, harvested wood requires additional consideration because some of the carbon may be stored in wood products in use and in landfills for several years or even centuries. Thus, some of the carbon removed from the ecosystem is rapidly emitted to the atmosphere while some carbon is transferred to other stocks in which case the emissions are delayed³⁹.

In non-forest ecosystems (i.e. cropland, grassland), biomass is predominantly non-woody perennial and annual vegetation, which constitutes a much smaller part of total ecosystem carbon stocks than in forest lands. Also, since non-woody biomass may turn over annually or within a few years, net biomass carbon stocks may remain roughly constant, although stocks may diminish over time if land degradation is occurring. Land managers may sometimes use fire as a management tool in grasslands and forests or wild fires may inadvertently burn through managed lands, particularly forest lands, leading to significant losses of biomass carbon. Fires not only return CO₂ to the atmosphere through combustion of biomass, but also emit other greenhouse gases, directly or indirectly, including CH₄, N₂O, NMVOC, NO_x and CO.

3.4.1 Forest Governance and Institutional Mechanism

Malaysia is administered by a federal system of government, where the administrative power, jurisdiction and related responsibilities are shared between the federal and state governments. The federal government provides advisory, technical guidance, training and research needs of the states. The 13 state governments have, inter alia, jurisdiction over agriculture, land and soil conservation, rivers, water and forest resources as provided under Article 74(2) of the Malaysian Constitution. In other words, the states are responsible for framing laws and policies independently for protecting their forests.

³⁹ IPCC, 2006

Other forestry-related environmental issues come under the concurrent list of the Constitution. Matters relating to Forest Management are governed and/or dealt with at the federal level by the Ministry of Natural Resources and Environment (upstream), and the Ministry of Plantation Industries and Commodities (downstream). The common ground of shared interests and objectives between the states and the federal government has been instrumental in keeping the state-federal relationship closely knitted on land and forestry issues. All the eleven states have adopted a common set of laws and regulations for forest management in Peninsular Malaysia. The states of Sabah and Sarawak have also aligned themselves with the initiatives and policies of the other states in Peninsular Malaysia.

A coordinated common approach to forest management is facilitated through the National Forestry Council (NFC), in action since 1972. The NFC harmonizes Sustainable Forest Management (SFM) policies and practices between Federal and State Governments. NFC is chaired by the Deputy Prime Minister and consists of all the Chief Ministers of 13 states⁴⁰. The NFC also includes heads of all forestry departments in Peninsular Malaysia, Sabah and Sarawak and the respective federal Ministers responsible for natural resources and the environment, finance, trade, agriculture and agro-based industries, plantation industries and commodities, science, technology and innovation.

The NFC was instrumental in the formulation of Malaysia's National Forestry Policy (NFP), which was later approved and adopted by the National Land Council (NLC) in 1978. The NFP has a number of special clauses and terms, with a view to ensure sustainability, while undertaking various forest management initiatives. This policy is unequivocally implemented by all the states in Peninsular Malaysia. Sabah and Sarawak have chosen to adopt an independent Forest Policy. However, in Sarawak, the Forest Policy – first adopted in 1954 by the Governor-in-Council – has similar provisions as the NFP. The NFP also provides for the maintenance of a Permanent Forest Estate (PFE), now better known as the Permanent Reserved Forests (PRF), to be managed along principles of sound forest management, as well as "Stateland" Forests outside the PRF, which are earmarked for non-forestry uses⁴¹. Several administrative institutions between federal and state governments are involved in sustainable forest management as reflected in Figure 3.4.2.

⁴⁰ Malaysian Timber Council, 2012

⁴¹ Ibid.

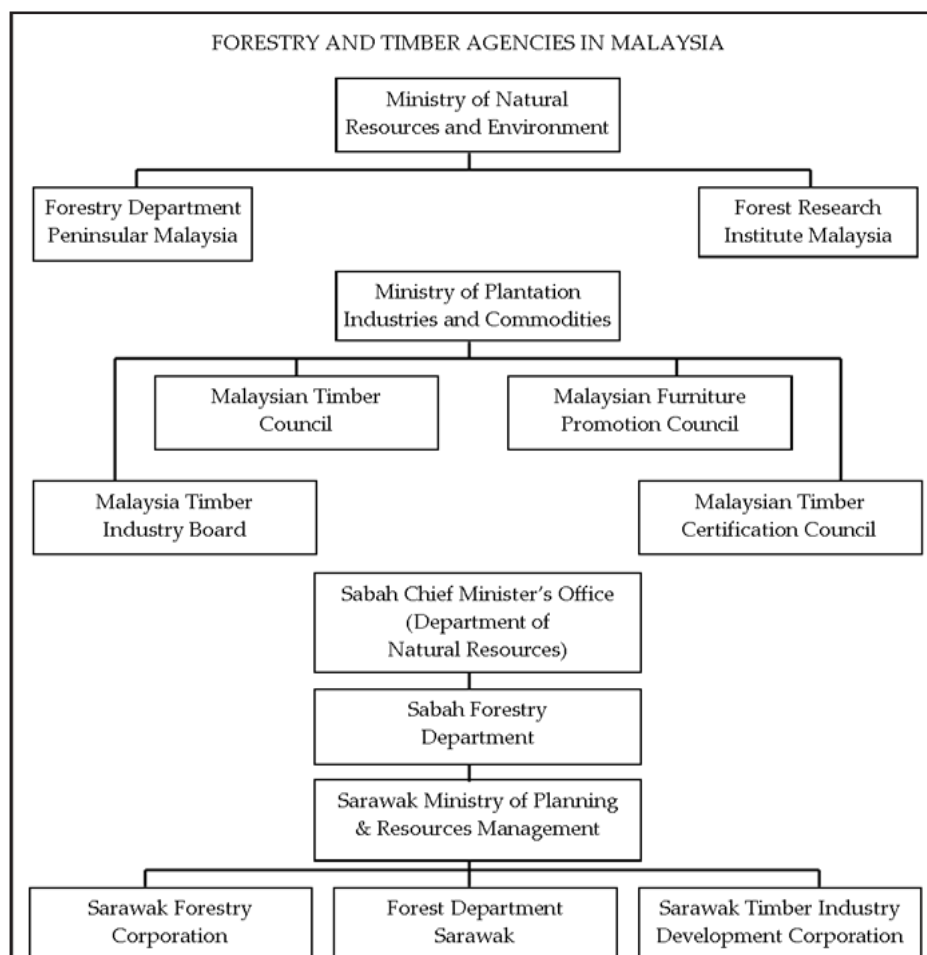


Figure 3.4.2: Institutional mechanism of forestry sector in Malaysia

Source: Malaysian Timber Council, 2011

3.4.2 Land Use

Area under forests comprises the largest land-use system in Malaysia. According to National Communication report (NC2, 2011) approximately 55.49% of the total land area are forested area. This included permanent reserved forests (PRF), totally protected areas (TPA), state land forests (SLF), national parks, and wildlife and bird sanctuaries. The remaining land use comprises of areas for agricultural crops, rubber and oil palm plantations, and urban or other uses. The Sabah and Sarawak regions are more forested as compared to Peninsular Malaysia, which is much more developed. The key feature of land use under the forestry sector is to maintain minimum 50% of geographical area under forests and to use state land forest only for the non-forestry purposes. PRFs and TPA cannot be diverted towards non forestry use. Table 3.4.1 shows the land use pattern by regions in Malaysia.

Table 3.4.1: Land use pattern by region in Malaysia for 2005 (million ha)

Region	Land area	PRF	TPA	SLF	FP	ATC	Other land uses	Total forest area	% of land under forest area	% of land under forest and ATC
Peninsular Malaysia	13.16	4.65	0.76	0.41	0.06	3.71	3.71	5.88	44.24	72.13
Sabah	7.37	3.31	0.27	0.56	0.21	1.30	1.72	4.35	59.06	76.67
Sarawak	12.31	4.76	0.49	2.77	0.02	0.71	3.56	8.04	65.34	71.07
Malaysia	32.98	12.72	1.53	3.74	0.29	5.71	8.99	18.28	55.49	72.75

Source: TERI Analysis, 2012 adapted from Lembaga Getah Malaysia, MPOB, Cocoa Board. Compendium of Environmental Statistics, 2006

FP: Forest Plantations PRF: Permanent Reserve Forests TPA: Totally Protected Areas SLF: State Land Forest ATC: Agriculture Tree Crop

The total forest area in 2005 was 18.28 million hectares (55.49% of Malaysia's total land area). Of this, 17.99 million hectares comprised natural forests (PRF, TPA and SLF) and 0.40 million hectares were forest plantations (FP). The agricultural tree crops (ATC), largely represented by oil palm plantations accounted for 5.71 million hectare of land. While agriculture tree crops sequester carbon substantially, these are currently not included within the category of "forest and tree cover" for purposes of reflecting the land area under forests. By including the land area under agriculture tree crops, total forest and tree cover in Malaysia would account for 23.99 million hectares, increasing land area under forests to 72.75%. Several other countries follow such categorization for agricultural tree crops, and it may be in Malaysia's interest to consider such re-categorization to not only align with existing policies, but also have greater flexibility in considering the scope for emission reduction possibilities from the climate change perspective.

Malaysia has designated 12.72 million hectares as permanent reserved forest and 1.53 million hectares as TPA. Permanent Reserve Forests are further categorised as Production Permanent Reserve Forests and Protection Permanent Reserve Forests. No harvesting or diversion of forests for non-forestry use is permitted in TPA and Protected PRF. Both these categories are largely managed and maintained for soil and water conservation, wild life conservation, and environment protection. Accordingly, land under TPA can be considered to fall in the category of Protected PRF including TPA. As a result, the PRF in Malaysia works out to be 14.25 mha as indicated in Table 3.4.2, which is 43.20% of the country's land area.

Table 3.4.2: Permanent reserved forests and totally protected areas by regions in Malaysia for 2005 (Million Ha.)

Region	Totally Protected Area (TPA)	Permanent Reserve Forests (PRF)	Total forest Area = TPA + PRF	% of total land area under PRF and TPA
Peninsular Malaysia	0.76	4.65	5.41	41.11
Sabah	0.27	3.31	3.58	48.58
Sarawak	0.49	4.76	5.25	42.65
Malaysia	1.53	12.72	14.25	43.20

Source: TERI Analysis, 2012 adapted from Lembaga Getah Malaysia, MPOB, Cocoa Board.
Compendium of Environmental Statistics, 2006

3.4.3 Forest Types

Malaysia is considered as one of the world's mega-diverse countries and its forests are rich in species. Accordingly, the LULUCF sector in Malaysia also holds relevance in terms of biodiversity and ecosystem services considerations. In terms of major forest types, estimates indicate that in 2005 Malaysia had 16.18 million ha of dry inland forest, 1.25 million ha of swamp forest, 0.56 million ha of mangrove forest, and 0.29 million ha of forest plantation⁴², with the proportion of forest areas being much higher in Sabah and Sarawak than in Peninsular Malaysia. The dry inland forest constitutes a major portion (88.51%) of the forest land, while forest plantation accounts for only around 1.64% of the total forested land. Table 3.4.3 presents the distribution and extent of major forest types by regions in Malaysia in 2005.

Table 3.4.3: Distribution and extent of major forest types in Malaysia for 2005 (million ha)

Region	Land area	Natural forest			Forest Plantation	Total Forest Area	Forest area as a percentage of total land area
		Dry inland forest	Swamp forest	Mangrove			
Peninsular Malaysia	13.30	5.46	0.26	0.10	0.06	5.88	44.21
Sabah	7.37	3.68	0.12	0.34	0.21	4.35	59.02
Sarawak	12.31	7.04	0.87	0.12	0.02	8.04	65.31
Malaysia	32.98	16.18	1.25	0.56	0.29	18.28	55.43

Source: TERI Analysis, 2012 adapted from Lembaga Getah Malaysia, MPOB, Cocoa Board.
Compendium of Environmental Statistics, 2006

⁴² APFSOS II, 2009

3.4.3.1 Growing Stock

The total growing stock in natural forests for all trees of 10cm diameter at breast height (DBH) and above in all regions of Malaysia is estimated at 4,426.77 million m³ ⁴³ and growing stock and merchantable volume of all trees having 45 cm DBH and above, excluding the mangrove forests is estimated to be 2,332.60 million m³ as indicated in Table 3.4.4. 92.3% of total growing volume stock of 10cm DBH and above is from dry inland forests, while growing stock in swamp forests and mangrove forests is comparatively much lower.

Table 3.4.4: Total growing stock and merchantable volume by region and major forest types in Malaysia for 2005 (million m³)

Region	Dry Inland Forest		Swamp Forest		Mangrove forests		Total	
	≥10 cm DBH	≥45 cm DBH	≥10 cm DBH	≥45 cm DBH	≥10 cm DBH	≥45 cm DBH	≥10 cm DBH	≥45 cm DBH
Peninsular Malaysia	1,357.91	898.06	81.60	18.30	24.50	0	1,464.01	916.36
Sabah	869.50	432.90	13.20	6.48	83.30	0	966.00	439.38
Sarawak	1,859.06	926.10	103.40	50.76	34.30	0	1,996.76	976.86
Malaysia	4,086.47	2,257.06	198.20	75.54	142.10	0	4,426.77	2,332.60

Source: APFSOS II, 2009

DBH= diameter at breast height, cm=centimetre

As indicated in Table 3.4.5, the total growing stock in Permanent Reserved Forests, estimated at the end of 2005 for all trees having 10cm DBH and above is 3,833.09 million m³ out of which 3,052.67 million m³ was from Production Permanent Reserved Forests and 780.42 million m³ from Protection Permanent Reserved Forests.

The total merchantable volume of all trees having 45cm DBH and above excluding mangrove forests, was 2,041.57 million m³ out of which 1,606.64 million m³ from Production Permanent Reserved Forests and 434.93 million m³ from Protection Permanent Reserved Forests. Production Permanent Reserved Forests are important from the carbon sequestration point of view, where as Protection Permanent Reserved Forests are important for biodiversity conservation and environment protection.

⁴³ APFSOS II, 2009.

Table 3.4.5: Total growing stock and merchantable volume of the permanent reserved forests (PRFs) by regions and functions in Malaysia for 2005 (million m³)

Region	Protection Forests		Production Forests		Total	
	≥10 CM DBH	≥45 CM DBH	≥10 CM DBH	≥45 CM DBH	≥10 CM DBH	≥45 CM DBH
Peninsular Malaysia	383.68	240.16	802.70	502.44	1,186.38	742.60
Sabah	145.26	71.74	741.09	366.02	886.35	437.76
Sarawak	251.48	123.03	1,508.88	738.18	1,760.36	861.21
Malaysia	780.42	434.93	3,052.67	1,606.64	3,833.09	2,041.57

Source: APFSOS II, 2009

In addition, the total growing stock from the forest plantations (0.40 million ha at present) which are planted mainly with *Acacia Mangium*, *Gmelina Arborea* and *Praserianthes Falcata*, is estimated to be 58 million m³, based on a weighted average of 145 cubic metre per hectare growing stock ⁴⁴.

3.4.3.2 Forest Carbon Stock

The total biomass from natural forest in Malaysia was estimated at 5,928.33 million tonnes out of which 4,780.91 million tonnes was above ground biomass and 1,147.42 million tonnes was below ground biomass in 2005. Based on IPCC “Good practice guidelines for land use land use change and forestry (2003)”, basic wood density of 0.5 tonnes per m³ on dry tonne basis and biomass expansion factor of 2.16 were considered as norms for estimation of the growing stock⁴⁵. A default value 0.24 of root to shoot ratio was considered for estimation of below ground biomass based on IPCC-GPG 2003. Accordingly, the biomass was estimated as indicated in Table 3.4.6.

Table 3.4.6: Biomass of the natural forests by regions in Malaysia for 2005 (million tonnes)

Region	Above-Ground Biomass	Below-Ground Biomass	Total
Peninsular Malaysia	1,581.13	379.47	1,960.60
Sabah	1,043.28	250.39	1,293.67
Sarawak	2,156.50	517.56	2,674.06
Malaysia	4,780.91	1,147.42	5,928.33

Source: APFSOS II, 2009

⁴⁴ APFSOS II

⁴⁵ IPCC-GPG2003

Adopting the default value of dead to live ratio of 0.15 from the IPCC-GPG, 2003, the dead wood biomass in Peninsular Malaysia, Sabah and Sarawak at the end of 2005 are estimated to be 294.09 million tonnes, 194.05 million tonnes and 401.11 million tonnes respectively, giving Malaysia a total dead wood biomass of 889.25 million tonnes in 2005.

In estimating the forest carbon stock in Malaysia, 0.5 tonnes of carbon per tonne of dry matter is considered as the default value of carbon fraction factor based on the IPCC-GPG, 2003 in order to estimate the amount of carbon stored in above-ground and below-ground biomass, as well as carbon in dead wood. A default value of 2.1 tonnes per ha of litter carbon stock of matured forests, also from the IPCC-GPG, 2003, is used to estimate the amount of carbon stored in the litter of the dry inland forests in Malaysia⁴⁶. The total carbon stock in the natural forests in Malaysia at the end of 2005 is accordingly estimated to be 3,442.33 million tonnes, (with the Peninsula, Sabah and Sarawak regions accounting for 1,138.71 million tonnes, 751.63 million tonnes and 1,551.99 million tonnes respectively).

Table 3.4.7: Carbon stock of the natural forests by regions in Malaysia for 2005 (million tonnes)

Region	Carbon in Above-Ground Biomass	Carbon-in Below-Ground Biomass	Carbon in Dead Wood	Carbon in Litter	Total carbon
Peninsular Malaysia	790.56	189.74	147.05	11.36	1,138.71
Sabah	521.64	125.19	97.03	7.77	751.63
Sarawak	1,078.25	258.78	200.55	14.41	1,551.99
Malaysia	2,390.45	573.71	444.63	33.54	3,442.33

Source: APFSOS II, 2009

3.4.3.3 Peat Land

Peat swamp forests are waterlogged forests growing on a layer of dead leaves and plant material up to 20 metres thick. They comprise an ancient and unique ecosystem characterized by water logging, with low nutrients and dissolved oxygen levels in acidic water regimes. Their continued survival depends on naturally high water levels that prevent the soil from drying out to expose combustible peat matter. This harsh waterlogged environment has led to the evolution of many species of flora uniquely adapted to these conditions⁴⁷. Tropical peat lands, besides acting as stores of carbon, actively accumulate

⁴⁶ APFSOS II, 2009

⁴⁷ Hans Joosten, 2010

carbon in the form of peat. Estimates suggest that 5,800 tonnes of carbon per hectare can be stored in a 10-metre deep peat swamp compared to 300-500 tonnes per hectare for other types of tropical forest (UNDP, 2006). Because decomposition is incomplete, carbon is locked up in organic form in complex substances formed by incomplete decomposition. Drainage of peat swamps destroys this useful function and may contribute to global warming through the release of CO₂ into the atmosphere⁴⁸. Recognition of carbon sequestration and storage by peat lands has therefore gained importance in recent years and due importance is being ascribed to management of peat.

Peat swamp forests constitute a significant component of Malaysian forests with around 69% of these located in Sarawak, 26% in Peninsular Malaysia and the rest in Sabah (Table 3.4.8).

Most of the carbon stored in peat lands is in the saturated peat soil that has been sequestered over the millennia. In the sub (polar) zone, peat lands contain on average 3.5 times more carbon per hectare than above-ground ecosystems on mineral soil; in the boreal zone they contain 7 times more and in the humid tropics over 10 times more carbon.

Table 3.4.8: Peat land in Malaysia (ha)

Region	Peat land (Hectares)	Percentage (%)
Peninsular Malaysia	642,918	26.16
Sabah	116,965	4.76
Sarawak	1,697,847	69.08
Total	2,457,730	100

Note: 7.45% of Malaysian Land is Peat Land, of which 70,303 ha is under forest, 1,069,125 ha is disturbed, 33,633 ha is under infrastructure, 874,844 ha is under agriculture and 6,042 ha is under water.

Source: Wetlands International, Malaysia, 2010.

Malaysia is conserving her peat swamp forest and the South Pahang Peat Swamp forest complex is one of the only tropical peat swamp forest in the world remaining intact. With an estimated 1.54 million hectares of peat swamp forest still remaining, the management of peat is also crucial to regulate carbon emission levels in Malaysia in future. While the country is already making efforts to conserve peat swamps, these efforts need to be continued to avoid emissions.

⁴⁸ FRIM-UNDP/GEF-2004

3.4.4 Forest Policies and Legislations

With the Forestry Department being established in 1901, initially forest management by Departmental Regeneration Improvement Felling (DRIF) was aimed solely at improving the existing stock through the removal of inferior species in the early 1920's. With rising demand for firewood and poles from the mining industries in the 1920's, Commercial Regeneration Improvement Felling (CRIF) was introduced⁴⁹. This involved a 5 year regeneration period coupled with several fellings.

The National Forestry Policy (NFP) adopted in 1978 was implemented through the National Forestry Act 1984 (NFA)⁵⁰ and holds for all the states of Peninsular Malaysia and Sabah. In Sarawak, the Forest Policy which was approved by the Governor-in-Council in 1954 has remained the basis for forestry practices⁵¹ and the State has its own forest and forest-related enactments and ordinances. However, it has similar provisions as in NFP adopted by Peninsular Malaysia and Sabah. In the Sarawak and Sabah regions, the Sarawak Forest Ordinance 1952 and the Sabah Forest Enactment 1968 govern management of the forests of these regions respectively.

The NFP and NFA were amended in 1992 and 1993 respectively in response to the UNCED conference in Rio de Janeiro in 1992. NFP was amended to accommodate global concern of the importance of biological diversity conservation and the sustainable utilization of forest genetic resources, as well as the role of local communities in forest development⁵². NFA was amended to strengthen its effectiveness in dealing with forest encroachment and illegal logging⁵³. The key features of the NFP as revised in 1992 are to dedicate areas of forest land as Permanent Forest Estate (Permanent Reserved Forests) throughout the country and to promote efficient harvesting and utilization within the production forest for maximum economic benefits. PRFs are to be managed and classified under four major functions, namely: production, protection, amenity, and research and education. During 1995-2005, Malaysia had increased its forest areas under the PRFs by 1.11 million ha⁵⁴.

3.4.4.1 Development of Criteria and Indicators

As a member of the International Tropical Timber Organization (ITTO), Malaysia is committed to the achievement of sustainable forest management. At national level 5 criteria and 27 indicators (C&I) were identified, while at the Forest Management Unit (FMU), 6 criteria and 30 indicators were identified. The National Committee on Sustainable Forest Management (SFM) was established in 1994 under the Ministry of

⁴⁹ Wyatt-Smith and Panton, 1995

⁵⁰ Woon and Norini 2002

⁵¹ APFSOS II 2009

⁵² APFSOS II, 2009

⁵³ Woon and Norini, 2002

⁵⁴ Ibid 50.

Primary Industries to ensure implementation of the C&I identified for sustainable forest management. Continuous monitoring of sustainable forest management is required to maintain the balance between conservation and production forestry.

3.4.4.2 Forest and Timber Certification

Timber and timber products export stood at RM 23.4 billion in 2006 and are exported to more than 150 countries ⁵⁵. The government of Malaysia recognizes the need to implement timber certification as a means to encourage and ensure SFM in line with the internationally agreed criteria and indicators. To facilitate timber certification, the Malaysian Government established the Malaysian Timber Certification Council (MTCC) in 1998. The MTCC operates as a non-profit organisation and as an independent national certifying and accrediting body ⁵⁶.

MTCC, based on a phased approach, had launched its Timber Certification Scheme in October 2001 using the Malaysian criteria and indicators (MC&I) for forest management certification. Currently, the MTCC has issued certificates for forest management to eight forest management units in Peninsular Malaysia, namely, the states of Johor, Kedah, Kelantan, Negeri Sembilan, Pahang, Perak, Selangor and Terengganu, covering 4.67 million hectares of the Permanent Reserved Forests, and the Sela'an-Linau Forest Management Unit in the state of Sarawak involving 55,949 hectares which were based on independent third party certification, and certificates for Chain-of-Custody to 55 companies in Malaysia ⁵⁷.

Malaysia is currently negotiating with the European Union on its Forest Law Enforcement, Governance and Trade (FLEGT) Voluntary Partnership Agreements, a licensing scheme that would exclude illegal raw timber, sawn-wood, plywood and veneer from entering the European market, as well as taking steps to submit the MTCC timber certification scheme for endorsement within the PEFC's framework for mutual recognition ⁵⁸. It is projected that by 2020, all timber and timber products produced in Malaysia will also be certifiable as legal and from sustainably managed forests by independent third party assessors consistent with internationally recognized timber certification schemes, including the Malaysian Criteria and Indicators for Forest Management ⁵⁹.

3.4.4.3 Forest Concessions

Concessions are provided to those that are willing to take up forest land to plant, rehabilitate and harvest on the lines of sustainable forest management. The tenure is proportionate to the area of land allotted. These concessions are awarded mainly to promote timber industry.

⁵⁵ Ibid 50

⁵⁶ Ibid 51

⁵⁷ UNFF, 2004

⁵⁸ APFSOS II, 2009

⁵⁹ Ibid 56

Sabah has included all the necessary guidelines into their licensing system for forest concessions called Sustainable Forest Management Licence Agreement (SFMLA) as the private companies are monitored and enforced against those conditions ⁶⁰.

3.4.4.4 Emphasis to Increase Area under Rubber and Forest Plantation

The forestry sector contributes more than 8% to the GDP of the country. In Malaysia, most of the rubber trees are used for providing timber rather than for latex. Over time, there has been an increasing shift from rubber plantations to oil palm plantations mainly due to the better financial returns from the latter and the long gestation period of rubber plantations (yields only after 15 years). To increase land under rubber plantation as envisaged in the National Agricultural Policy (NAP 1992-2010) considering the importance of the sector as it is used as raw material for approximately 80% of the furniture exported, the Malaysian Government has taken steps to provide better incentives through the Pioneer Status (PS) and Investment Tax Allowance (ITA) schemes, introduced through the Promotion of Investment Act (PIA) 1986. The incentive schemes for forestry plantations would definitely attract companies to grow more trees which would reduce the pressure on natural forests on one hand, and also maintain the sector's contribution to the GDP of Malaysia on the other hand.

The Government is also aggressively pursuing the establishment of more forest plantations and disbursing soft loans for private companies willing to establish forest plantations. Through this initiative, the Government plans to develop 375,000 ha of forest plantation in the next 15 years, at an annual planting target of 25,000 ha, which is expected to yield 5 million m³, at an estimated total cost of RM 2.2 billion (APFSOS II 2009). The Government provides RM 5,400 and RM 3,200 for companies to plant 1 ha of rubber and non-rubber species respectively, where upon harvesting the matured trees the companies have to repay the Government at 3.5% for the soft loans provided to them. As per the Malaysia forestry outlook study ⁶¹, six companies have been selected to plant a total of 16,100 ha and loans amounting to RM 80.34 million have been disbursed to them. The progress on this, including its implication for emissions needs to be evaluated further.

Sabah has set a target of 500,000 ha of forest plantation by year 2020, while Sarawak is expected to have 1.2 million ha of established forest plantations ready for harvesting from 2011 onwards. This is based on the fact that Sarawak had awarded 39 licences for Planted Forests, covering 2.4 million ha, to the private sector to establish forest plantations in addition to the Government's forest plantation covering 500,000 ha ⁶². The total plantation in 2020 is projected to be 2.15 million hectares. From the economic perspective, agriculture crops are not too lucrative. It may be possible to shift around 1 million hectare agriculture land towards plantation of tree species under agro-forestry programme by 2030.

⁶⁰ Traffic International, 2004

⁶¹ Ibid 56

⁶² APFSOS II, 2009

3.4.5 Land-Use Policy

The Malaysian agricultural sector can be primarily grouped into three sub-sectors. The agro-industrial sub-sector (comprising oil palm, rubber, cocoa and timber) which mainly serves the export market; the food sub-sector (paddy, fruits and vegetables, livestock and fisheries), which largely serves domestic consumption and the third sub-sector, the miscellaneous group (tobacco, pepper, coconuts, sugarcane, cassava, sweet potato, maize, tea and coffee) which caters to both the domestic and export markets.

In the 1960s and 70's the focus was towards expansion of paddy and the agro-industrial sub sector, considering the presence of abundant land and cheap labour. This continued with the formulation of the first National Agricultural Policy (NAP1 – 1984-1991), which laid emphasis on developing the export sector. The NAP2 1992-1997 laid emphasis on productivity, efficiency and competitiveness in the context of sustainable development and increased area for plantation. The focus shifted from new area development to in-situ development. During this period there was acute labour shortage, competing land and water resources, due to globalization and liberalization and high import costs of food items.

The Third National Agricultural Policy (NAP3- 1998-2010) set strategic directions for agricultural and forestry development up to 2010. This policy has been formulated to ensure that the capability of the agricultural sector to play its strategic role in national development is sustained and enhanced in light of new and emerging challenges facing agricultural development. Towards this end, NAP3 focused on new approaches to increase productivity and competitiveness, deepen linkages with other sectors, venture into new frontier areas as well as conserve and utilise natural resources on a sustainable basis. The policy aims to set in place the enabling and supportive measures as well as a conducive environment to promote growth in the agricultural sector. Accordingly, NAP3 focused on sustainable development of agro-food and agro based industries through moderate expansion of land and further intensification of land use. The policy noted an expected decline in contributions from rubber, cocoa and sawn logs while the contribution from oil palm and food commodities were expected to increase. Oil palm and rubber are important agricultural crops for the country that provide income and employment. Efforts are made to ensure that growth in these crops is in line with the sustainable development goals of the country. There has been a decline in the land area planted with rubber, cocoa and paddy. Nonetheless, the land planted with paddy is still rather stable because rice is a staple food in Malaysia, as in many countries in South East Asia.

Over the period 1985 to 2005, the total area under perennial agricultural tree crops had increased from 3.75 million ha to 5.70 million ha, an increase of 1.95 million ha, with areas under oil palm plantations more than doubling from 1.47 million ha in 1985 to 4.05 million ha in 2005. It is foreseen that there will be no new opening of lands for the large-scale planting of perennial agricultural tree crops in Peninsular Malaysia, especially oil palm, as under the Third National Agriculture Policy, 1998-2010, such new plantings will only occur

in Sabah and Sarawak where there is still ample land available. As such, the pressure to convert forest lands in Peninsular Malaysia to permanent non-forestry uses will be reduced while allowing the Forestry Departments to increase their efforts to manage the forests sustainably⁶³.

Malaysia needs to have regulatory mechanism at federal government level to maintain minimum 50 per cent forests in the country and no more forest diversion for non-forestry use after 2020 should be allowed. If there is need to divert in emergency, equivalent area should follow from non-forestry sector to forestry use. Malaysia also needs to widen the scope of definition of forests to include area under agriculture tree crops under forest and tree cover.

3.4.6 Future Land Use Pattern

3.4.6.1 Forestry Scenario in 2020

Malaysia is committed to maintain a minimum of 50% forest cover and enhance the carbon sequestration by 2020 and beyond. The mandate of forest policy of Malaysia is to achieve sustainable forest management, and also implementing practices of sustained yield management. The sustainable forest management (SFM) concept in Malaysia is focused on sustained yield from the forest and conservation of biodiversity. To meet the objective of SFM, Malaysia has to keep forest areas under conservation reserve and production reserve. The forest area has been kept under TPA and Protection PRF where no felling is permitted and production PRF where logging is permitted on the principle of sustained yield, and also the forest plantation areas where commercial plantations are raised.

Most of the countries are keeping 5-10% of their geographic area under conservation reserve to maintain the ecological balance in their countries. Given the importance of forestry sector contribution to the country's GDP, it is also important to keep substantial area under production permanent forest reserve to maintain the continuous wood supply as well as maintaining the ecological services. Forest plantations and agriculture tree crop will be providing exclusively wood production and other economic activities along with carbon sequestration as co-benefit.

Malaysia has 14.26 mha areas under PRF and TPA, 3.74 mha under state land forest and 0.29 under forest plantations in the past. Malaysia now has the option keeping the above points into consideration, to divert state forest land towards PRF, forest plantations and agriculture tree crops. On the basis of existing policies, the possible land use in 2020 would be 12.72 under PRF, 1.53 mha under TPA, 0.29 mha under FP and 5.72 mha under ATC. It is important to mention here that in this case, no state land forest would be available by 2020 and beyond. There is another option to use some of the agriculture land for plantation of fast

⁶³ APFSOS II, 2009

growing tree species to maintain wood production and enhance carbon sequestration keeping factor of food sufficiency into consideration. With this land use pattern, Malaysia can achieve the objective of maintaining ecological balance and also maintaining the contribution of the forestry sector in GDP.

On the basis of land use pattern in 2005, policies of Peninsular Malaysia, Sabah and Sarawak, and also on the basis of research papers, the land use pattern in 2020 would be as shown in Table 3.4.9.

Table 3.4.9: Projected land use pattern of Malaysia in 2020 (million ha)

Region	Land Area	PRF	TPA	SLF	FP	ATC	Other Land Use	Total Forest Area	Area under Forests and tree Cover
Peninsular Malaysia	13.30	4.65	0.76	0.41	0.06	3.71	3.71	5.88	9.59
Sabah	7.37	3.31	0.27	0.38	0.21	1.30	1.90	4.18	5.47
Sarawak	12.31	4.76	0.49	2.07	0.02	0.71	4.27	7.34	8.04
Malaysia	32.98	12.72	1.53	2.56	0.29	5.71	9.87	17.40	23.11

PRF: Permanent Reserve Forests TPA: Totally Protected Areas SLF: State Land Forest FP: Forest Plantations
ATC: Agriculture Tree Crop

Source: TERI Analysis, 2012 adapted from Lembaga Getah Malaysia, MPOB, Cocoa Board.
Compendium of Environmental Statistics, 2006

3.4.6.2 Forestry Scenario in 2030

Maintaining minimum of 50% forest cover, the total forest cover in Malaysia is expected to be 16.49 million hectare by 2030. As per the technical definition of forests given by FAO, the agriculture tree crop areas may also be considered as forests if the area is more than 0.5 hectare with more than 10% crown cover with minimum five meter height of trees. Then the total forest cover including ATC is 22.21 mha. Most of the agriculture tree crop areas may come under this definition. Accordingly, the details of the projected land use pattern in 2030 would be as shown in Table 3.4.10.

Table 3.4.10: Projected land use pattern of Malaysia in 2030 (million ha)

Region	Land Area	PRF	TPA	SLF	FP	ATC	Other Land Use	Total Forest Area	Area under Forests and tree Cover
Peninsular Malaysia	13.30	4.65	0.76	0.41	0.06	3.71	3.71	5.88	9.59
Sabah	7.37	3.31	0.27	0.20	0.21	1.30	2.25	4.00	5.29
Sarawak	12.31	4.76	0.49	1.34	0.02	0.71	5.70	6.61	7.32
Malaysia	32.98	12.72	1.53	1.95	0.29	5.72	10.78	16.49	22.21

PRF: Permanent Reserve Forests TPA: Totally Protected Areas SLF: State Land Forest FP: Forest Plantations

ATC: Agriculture Tree Crop

Source: TERI Analysis, 2012 adapted from Lembaga Getah Malaysia, MPOB, Cocoa Board.

Compendium of Environmental Statistics, 2006

Malaysia has adopted the policy for biodiversity conservation, and also committed to implement global forest objectives for the sustainable development of forests. The area under PRF and TPA is expected to be 14.25 million hectare by 2020 and also in 2030. The projection is based on the fact that Malaysia will maintain its commitment to have minimum 50% forests of the geographical area. The details are shown in Table 3.4.11.

Table 3.4.11: Projected land use and PRF in 2020 (million ha)

Region	Land Area	Permanent Reserve Forests		
		Protection (Including TPA)	Production	Total
Peninsular Malaysia	13.30	0.76	4.65	5.41
Sabah	7.37	0.27	3.31	3.58
Sarawak	12.31	0.49	4.76	5.25
Malaysia	32.98	1.53	12.72	14.25

Source: TERI Analysis, 2012 adapted from Lembaga Getah Malaysia, MPOB, Cocoa Board

Compendium of Environmental Statistics, 2006

3.4.7 Carbon Sequestration Scenario

The productivity of forests in Malaysia is 2-2.5 m³ per hectare per year. The selective management system is used for the management of forests. The harvest is 40-50 m³ timber per hectare at the cycle of 30 years. The annual increment in the above ground biomass of tropical rainforest is 3.4 tonnes per hectare per year and 6.93 tonnes per hectare per year in

moist deciduous forests and 11.79 tonnes per hectare per year in dry forests⁶⁴. Around 88% forests come under dry inland forest and 12% forests are swamp forests and mangrove forests. The above ground biomass growth in forest plantations is 15 tonnes per hectare per year⁶⁵. There are agriculture tree crop which sequester carbon. The average increment in the biomass increment is 8.3 tonnes per hectare per year⁶⁶. The default value of 24% has been considered for the calculation of below ground biomass⁶⁷. According to NC2, the carbon sink is 240.5 MtCO₂ eq. The emission from LULUCF is estimated to be 25.3 MtCO₂ eq. which yield a net sink of 215.2 MtCO₂ eq. as mentioned in Table 2.4 of the NC2 Report. The BAU carbon sink in 2020 is shown in Table 3.4.12. The total carbon sink in 2020 is projected as 431.80 MtCO₂ eq.

Table 3.4.12: Estimation of carbon sink in 2020 (MtCO₂ eq.) - BAU

Region	PRF	TPA	SLF	Forest Plantation	Agriculture Tree crop	Total
Peninsular Malaysia	79.49	5.88	10.37	2.05	85.00	180.75
Sabah	56.59	2.11	9.62	5.24	29.59	96.40
Sarawak	81.39	3.81	51.77	0.47	16.17	147.13
Malaysia	217.47	11.81	71.77	7.76	130.75	431.80

Note: Default Values for Carbon Removal Estimation: AGB 6.93 T /Y/ha for 88% and 11.79 T/Y/ha for 12% (PRF) 15 T /Y/ha AGB for Forest Plantations, AGB 3.4 T /Y/ha for 88% and 3.4 T/Y/ha for 12% (TPA) 8.3 T/Y/ha Biomass growth (ATC)

Source: TERI Analysis, 2012 adapted from Lembaga Getah Malaysia, MPOB, Cocoa Board. Compendium of Environmental Statistics, 2006

Malaysia is committed to maintain a minimum of 50% of its land under forest area from 2030 and beyond. The carbon sink in 2030 is estimated to be 409 MtCO₂ eq. as shown in Table 3.4.13.

⁶⁴ IPCC, 2006

⁶⁵ Ibid 64

⁶⁶ MPOC-2006

⁶⁷ Ibid 64

Table 3.4.13: Carbon sequestration (MtCO₂ eq) in 2030-BAU

Region	PRF	TPA	SLF	Forest Plantation	Total	Agriculture Tree crop	Total
Peninsular Malaysia	79.49	5.88	10.37	2.05	95.75	85.00	180.75
Sabah	56.59	2.11	5.06	5.24	63.76	29.59	93.35
Sarawak	81.39	3.81	33.53	0.47	118.74	16.17	134.90
Malaysia	217.47	11.81	48.97	7.76	278.24	130.75	409.00

Note: Default Values for Carbon Removal Estimation: AGB 6.93 T /Y/ha for 88% and 11.79 T/Y/ha for 12% (PRF) 15 T /Y/ha AGB for Forest Plantations ,AGB 3.4 T /Y/ha for 88% and 3.4 T/Y/ha for 12% (TPA) 8.3 T/Y/ha Biomass growth (ATC)

Source: TERI Analysis, 2012 adapted from Lembaga Getah Malaysia, MPOB, Cocoa Board. Compendium of Environmental Statistics, 2006.

3.4.8 Emission Scenario

On the basis of default value of IPCC guidelines for the emissions from forest area, Malaysian forests and tree crop area will be emitting 27.8 MtCO₂ eq. in 2020. The log harvest converted in the form of furniture and building material does not produce emissions in the same year but once harvested, it could result in emissions after a long period of storage of carbon. The emission from wood harvest is 4.86 MtCO₂ eq. The total emission for 2020 BAU scenario is 33.26 MtCO₂ eq. Similarly, emissions from forest and tree crop area is estimated to be 16.38 MtCO₂ eq. in 2030. The emission from wood harvest is 11.66 MtCO₂ eq. The total emission for 2030 BAU scenario is 28.04 MtCO₂ eq.

It must also be noted that emissions from biodiesel produced from oil palm are not accounted for within the Land Use, Land-Use Change and Forestry Sector, but are taken care of in the industrial and transport sectors.

Future emissions will also depend upon efficient fire control and management of peat lands. The natives of Sarawak enjoy the native customary rights (NCR) for the use of land and land resource, and at times also practice shifting cultivation, which is one of the sources of emissions from this sector. There is a big scope for creating alternative livelihoods for this section of population by providing them with alternative employment opportunities through non-timber forest produce and its value added products.

Based on the historic rate of deforestation in Peninsular Malaysia, Sabah and Sarawak, the estimated forested land for conversion from 2011 through 2020 is 1 mha which still provide 52.76 % of total land area of the country to be covered by forest. Two mitigation scenarios were projected which represent a 10% and 20% reduction in the rate of forest conversion. Similarly, the logging intensity is also projected to have 10% and 20% rate of reduction in logging intensity. From year 2021 to 2030, 0.91 mha is projected to be further converted. By this projection the forest cover in 2030 will be 50% of the total land area for the country. The values for year 2020 and 2030 are presented in Table 3.4.14 and 3.4.15 respectively.

Table 3.4.14: Projected estimation of carbon emission (MtCO₂ eq.) in 2020

Scenario	Emission from the forest conversion, Mt CO ₂ eq.	Emission from the logging intensity, Mt CO ₂ eq.	Total emission, Mt CO ₂ eq.
Business-as Usual, BAU	27.8	4.86	32.66
10% reduction in rate of deforestation	25.02	4.37	29.39
20% reduction in rate of deforestation	22.24	3.89	26.13

Source: TERI & UNITEN Analysis, 2012

Table 3.4.15: Projected estimation of carbon emission (MtCO₂ eq.) in 2030

Scenario	Emission from the forest conversion, Mt CO ₂ eq.	Emission from the logging intensity, Mt CO ₂ eq.	Total emission, Mt CO ₂ eq.
Business-as Usual, BAU	16.38	11.66	28.04
10% reduction in rate of deforestation	14.74	10.49	25.24
20% reduction in rate of deforestation	13.10	9.33	22.43

Source: TERI & UNITEN Analysis, 2012

In conclusion, the carbon sequestration and emission for 2005, 2020 and 2030 are presented in Table 3.4.16.

Table 3.4.16 : Overall projection of CO₂ sequestration (MtCO₂ eq) for forestry and land use.

CO ₂	2005*	2020		2030	
		BAU	AMB	BAU	AMB
(a) Emission (Source)	25.3	32.66	26.13	28.04	22.43
(b) Sink	240.5	431.8	431.8	409.0	409.0
(c) Net Emission	- 215.2	-399.14	-405.67	-380.96	-386.57
(c) = (a) – (b)					

* from NC2, 2011

The annual projected expenditure on forest administration and expenditure on forest development and forest plantation is estimated to be RM 372 million⁶⁸ and RM 435 million⁶⁹. Against this, the expected annual revenue from the log harvest is estimated at RM 1,833 million⁷⁰.

The net carbon sequestration in 2020 will be 265 million tonnes that may be valued at RM 4,252 million⁷¹ at the rate RM 16 per tonne certified emission reduction (CER).

The plantation cost is RM 7,000 per hectare and there is need to plant further 1,750,000 hectare in 15 years. The plantations are being done gradually on annual basis. Therefore, 100% expenditure will actually not be incurred in one year. Since, plantations will be replaced on the basis of rotation of plantations, expenditure for only one year has been taken into consideration. The plantation cost of agriculture tree crops such as oil palm is around RM 50,000 with 10% maintenance each year and the rotation of the crop is 20 years (NRE, 2012). The annual benefit from oil palm plantations is estimated at RM 8,400 per hectare per year. The net financial benefit from oil palm sector would be RM 5,650 per year per hectare. The total expenditure from 2020 onwards on forestry and agriculture tree crops would be RM 3,010 million and revenue from this sector is estimated to be RM 4,155 million as notional revenue. It will also sequester carbon equivalent to RM 4,252 million. At present it is notional revenue.

Forest provides many ecosystem services. At this juncture, only carbon sequestration and timber and non-timber forest produce have been taken into consideration while other ecosystem services such as biodiversity conservation and watershed protection are ecosystem services which have not been taken into consideration due to non-availability of their values. Malaysia has to develop its capacity for the valuation of ecosystem services and also the mechanism of REDD+ and CDM for Afforestation Reforestation (CDM-AR) activities. It is very difficult to put a price tag on nature. However, the implementation of sustainable forest management is not only cost effective, but would also derive more benefits if Malaysia could make use of CDM-AR and REDD+ carbon incentive opportunities.

⁶⁸ APFSOS II, 2009

⁶⁹ Ibid 68

⁷⁰ Ibid 68

⁷¹ TERI ANALYSIS, 2012

3.4.9 Action Plan for Implementation

The Roadmap for Malaysia's forestry sector is proposed keeping in mind the options available to the country and the changes development perspective in mind. Some of the recommendations need to be taken immediately are as follows:

Short Term:

- i. The tree cover in notified forest areas and area under agriculture tree crop may be considered as forest and tree cover for Malaysia as per the technical definition of forests given by FAO. This could take the land area under forests to around 72.8%. Forests provide various ecological services including carbon sequestration while plantation of fast growing species provides high rate of carbon sequestration but lacking biodiversity conservation. Emissions will increase with the high economic growth. High rate of carbon sequestration is needed to counter high rate of emission. A balance has to be maintained between conservation and production forestry. Malaysia has adequate area under conservation forestry, particularly biodiversity conservation (around 7.4% of geographical area).
- ii. Implementation of silvicultural practices, particularly in the production PRFs is very important to maintain the production as well as the natural regeneration. This activity is very crucial for enhancing productivity as well as carbon sequestration. More emphasis is needed for higher fund allocation and implementation of silvicultural practices.
- iii. The reforestation and afforestation initiatives can be further enhanced via tree planting campaign. Urban plantation shall be encouraged.
- iv. Adequate allocation of financial resources and building capacity of the forest officials for the sustainable forest management.
- v. Conduct studies for the economic valuation of ecosystem services.
- vi. Increase efforts to prepare the country for REDD+. Pilot studies, awareness and capacity building is needed. Voluntary markets are available for the carbon trade under REDD+.
- vii. The indigenous people who has native customary rights for the use of land and land resources could be provided with alternate natural resource based livelihood to avoid shifting cultivation. This will help in reducing emissions.

Long term:

- i. Every avenue should be explored for reducing the rate of deforestation and forest degradation. Promotion of sustainable forest management needs to be maintained and supported via local or international funding. The peat areas should be managed effectively to restrict the emission, particularly in Sarawak region.
- ii. The inter-agency coordination should be strengthened at the federal, state and forest management unit level to ensure sustainable forest management, conservation and development of forest resources in Malaysia. This would involve horizontal and vertical coordination, as well as enhance information flow and accountability between the different tiers of the governments.
- iii. Review the National Forestry Act, 1984 and other forest related laws so as to simplify and remove contradictions, inconsistencies and overlapping jurisdictions between the laws, especially those provisions supporting sustainable forest management and in curbing the illegal forest harvesting activities and trade in illegal timber products.
- iv. Updating the National Forest Policy is necessary to fulfil the post climate change obligations.
- v. The peat areas should be managed effectively to restrict the emission particularly in Sarawak region.
- vi. Plantation of high yielding species in the plantation areas would provide higher rate of carbon sequestration on one hand and large volume of wood on a shorter rotation to meet the growing demand of revenue from forestry sector.
- vii. Malaysia should strengthen the export of value added products of timber to generate more revenue out of low harvest of forests. The harvest must be on the silvicultural principles and norms.
- viii. More thrust on research and development to enhance productivity through better silvicultural practices, high yielding varieties of plant species and better logging practices.
- ix. There is a need to have regulatory mechanism at federal government level to regulate diversion of forest land for non-forestry purposes to maintain the commitment of having minimum 50% area under forests.
- x. Co-ordinated and integrated planning for forest plantation, agriculture tree crop and forests would help in implementation of consistent policies and measures.
- xi. There is a need to build capacity and technology for the assessment of forest cover, forest density and biomass.

Malaysia is a forest rich country having different category of forests such as Permanent Reserved Forests (PRF), state land forests (SLF), totally protected areas (TPA and forest plantations (FP). Logging is permitted only in production PRFs, state land forests and forest plantations. Logging is not permitted in Protection PRFs and totally protected areas. PRFs and totally protected area cannot be transferred for non-forestry purpose. Malaysia has only state forest land to divert for no-forestry use, including the plantation of agriculture tree crops.

Malaysia has committed during Earth Summit in 1992 to maintain a minimum of 50% of geographical area under forests. Malaysia is diverting forests for economic activities including plantation of agriculture tree crops. There is a continuous decline in the forest area since 1985.

It is commendable that Malaysia had started its National REDD+ strategies initiative since 2012. The vision of the national REDD+ strategies is to assure that forest resources and ecosystem services are secured, and that benefits are shared fairly and equitably among all stakeholders. It looks into three main components: the institutional, legal and policy framework, sustainable financing structure and payment mechanisms. With these initiatives, it is possible to reduce the rate of forest conversion. The challenges are the land legislation issue across Peninsular Malaysia, Sabah and Sarawak and also receiving international funding to support REDD+ initiatives. Sabah has started formulating its own state REDD+ roadmap for conservation of forests and biodiversity. Another commendable initiative is the introduction of "Heart of Borneo" by Malaysia, Brunei and Indonesia for the conservation of forest in Borneo.

Malaysian Timber Certification Council (MTCC) is an independent organisation which develop and operate a voluntary national certification scheme in Malaysia to ensure continued viability and sustainability of Malaysia's forest industry. MTCC issues two types of certificates: Certificate for Forest Management to Forest Management Units (FMUs) and a Chain-of-Custody (COC) Certification to timber products manufacturers and exporters. It assures that the harvested wood products are from sustainable forest management practices. The MTCC certification scheme has been accepted internationally by countries such as Denmark, UK, Japan, France and New Zealand.

The National Physical Plan (NPP) provides an efficient, equitable and sustainable national spatial framework to guide the overall development of the country toward achieving developed nation status. It aims to provide an integrated framework for sustainable land use planning, focusing on sustainable management of environmental sensitive areas (ESA), safeguard water resources and conserve prime agricultural land. One of the trusts is to establish Central Forest Spine (CFS) to be the backbone of environmental sensitive area network. The execution of this plan will enhance forest conservation.

The business as usual scenario in 2020 is estimated to have a net sink of 399.14 MtCO₂ eq. In the ambitious scenario where the rate of forest conversion and logging intensity is reduced by 20%, the LULUCF sector will have a net sink of 405.67 MtCO₂ eq.

The business as usual scenario for 2030 is estimated to have a net sink of 380.96 MtCO₂ eq. A 20% reduction in the rate of forest conversion and logging intensity will be able to increase the sink to 386.57 MtCO₂ eq.

Forest is a state subject in Malaysia. At present, while the States are free to make laws and policies, the Federal Government has little control over the management of forests. Accordingly, it is suggested that the federal government should have higher level of control to bring about integrated working in this sector across the entire country. Peninsular Malaysia region is following National Forest Policy but Sarawak and Sabah have their own forest policies.

Malaysia should adopt the approach of sustainable management of forests along with biodiversity conservation and maintenance of ecosystem services. Malaysian forest management suffers from inadequate financial resources and inadequate capacity. Strengthening of federal and state government linkages is needed to implement sustainable management of forests, and also to maintain international commitments.

LULUCF sector plays a salient role in providing sequestration option for GHG emission in Malaysia. Mitigation efforts in reducing the rate of deforestation and forest degradation and forest conservation will support initiatives in maintaining a minimum of 50% forest cover. The timber certification scheme encourages timber industries to apply sustainable forest management practice. It is critical to preserve and manage peat swamp sustainably in order to conserve the carbon stock. The national REDD+ initiative is a step forward in right direction to maintain natural forest. However, the success of REDD+ initiative is dependent upon the successful creation of new market mechanisms, resolving legislation barriers on land jurisdiction and getting appropriate funding from international communities and local support from private and public entities. Thus, with sufficient financial support from international communities coupled with efficient implementation of government policies, Malaysia shall be able to preserve its ecosystem and biodiversity towards sustainable development.

3.5 Agriculture Sector

Malaysia's main agricultural products include palm oil, rubber, cocoa, rice, coconuts, pepper and number of fruits and vegetables for the domestic market.

The climate of Malaysia is conducive for large number of exotic species. Being close to the equator, the weather is hot and humid round the year. As most of the land mass is under hilly terrain, the flat land is inadequate to produce enough food for its population and the country depends heavily on imports ⁷².

3.5.1 Planted Areas of Major Agricultural Crops in Malaysia

The Third National Agricultural Policy (NAP3) noted an expected decline in contributions from rubber, cocoa and sawn logs while the contribution from oil palm and food commodities were expected to increase. The main thrust of the policy was to focus on new approaches to increase productivity as well as conserve and utilize natural resources in a sustainable manner.

Oil palm and rubber have traditionally been the important agricultural crops for the country providing opportunities for income generation and employment. Efforts have been made to ensure that the growth of these crops is in line with the sustainable development goals of the country. There has, however, been a decline in the land area planted with rubber and cocoa in recent years. Nonetheless, the area planted with paddy is rather stable because of its importance as the staple food. Overall the production of rice has increased despite the marginal reduction in the area planted. Area under cultivation for most of the crops has marginally increased with the exception of rubber and cocoa (Table 3.5.1).

The Government's initiatives towards attaining self-sufficiency in rice are as follows:

- a) Increasing number of harvests each year. Malaysian Agricultural Research and Development Institute (MARDI) has successfully demonstrated rice harvest up to five crops in every two years.
Taking two crops a year is feasible in all the regions of Malaysia provided irrigation facilities are available.
- b) Providing certified seeds and heavy subsidies on farm inputs (fertilizers and pesticides) to the farmers who are using certified seeds. Two varieties (MR 219 and MR 220) are cultivated in over 80% of the planted area.

The foundation seed is produced by MARDI and through Department of Agriculture is given to the seed companies who in turn under license, produce certified seeds. The subsidies on fertilizers are provided only to those companies which maintain high production standards. In spite of monoculture, the country has never faced any major instance of disease. The yield variations are from 4-7 tonnes per hectare (may go up to 10 tonnes) and are largely correlated with the availability of water.

⁷² Agriculture's share is 12% of the national GDP and 16% of the population is employed in Agriculture

Department of Agriculture and MARDI have prepared 'Rice Production Manual'. Farmers get themselves registered with the cooperatives that provide them with all the help for procuring seeds and other inputs and finally marketing of the produce. The farmers' whose production is higher than the average, further gets incentives such as higher selling price (up to 30% higher).

Average farm size is 1.2 hectare but leasing of additional land is common. Large scale use of machines is in practice due to non-availability of labour. Labour is very expensive and is not readily available. Due to adequate rainfall in most part of Malaysia, there is no need for ground water extraction. The water is taken through canals to the rice fields.

Vegetables and fruits are locally produced. The seeds of most vegetables are imported but for fruits, seeds are locally produced and even exported (such as for water melon). Organic cultivation is gradually gaining popularity through vermicomposting and application of mycorrhizae. While drip irrigation is applied for banana, sprinklers are commonly used for vegetable crops. The environment is conducive for most crops and production is either adequate or met through imports (Table 3.5.2 on self-sufficiency levels) and nutritional security is met at all levels. Less than 5% of the total cultivated land is irrigated.

Table 3.5.1: Agriculture land use, 1995-2010

Crop	'000 hectares			
	1995	2000	2005	2010
Oil Palm	2,508	3,377	4,051	4,555
Rubber	1,727	1,431	1,250	1,179
Paddy	480	478	452	450
Fruits	244	304	330	375
Coconut	273	159	121	180
Cocoa	234	76	33	45
Vegetables	42	40	64	86
Tobacco	10	15	10	7
Pepper	10	13	13	14
Total	5,528	5,893	6,324	6,891

Source: Malaysian Directory and Index, 2009/2010

The decline in the area under rubber plantation is largely due to shortage of manpower. Even existing plantations of rubber are not tapped adequately. Oil palm plantations are easy to manage and major activities (such as farm preparation, irrigation, harvesting, etc) are all mechanised. Further, Malaysia is witnessing increase in rainfall, which is resulting in less latex production in rubber but more yields in case of oil palm. Land under agriculture is also getting converted into oil palm plantation mainly because of the ease in raising plantations and in many regions, is under threat by real estate developers.

Table 3.5.2: Self-sufficiency levels in food commodities (%), 2000-2010

Commodity	2000	2005	2010
Rice	70	72	71.4*
Fruits	94	117	138
Vegetables	95	74	108
Fisheries	86	91	104
Beef	15	21	28
Mutton	6	9	10
Poultry	113	129	122
Eggs	116	109	115
Pork	100	102	132
Milk	3	5	5

Source: Malaysian Directory and Index, 2009/2010.

*Dasar Agro Makanan Negara 2011-2020.

3.5.2 Livestock Population

Consumption of meat in Malaysia is higher than the supply and the gap is met through imports. The government's plan is to increase livestock production from the present 15% to 40% self-sufficiency or about 1.5 million cattle, thus demanding major investments in research for this sector.

Table 3.5.3: Selected livestock population in Malaysia

Livestock	2000	2005	2010
Cattle	733,892	781,316	796,550
Goat	237,634	287,670	335,952
Sheep	157,070	115,922	110,415
Swine	1,807,590	2,035,647	2,027,561
Poultry	123,650,000	174,694,170	215,822,110

Source: NC2, 2011

3.5.3 Livestock Production Dominated by Poultry

Table 3.5.3 indicates that production increase in the livestock sector have been relatively strong, with annual average productivity growth of around 3.7% achieved. The improvement in breed through genetics has been the major contributor to productivity growth in the livestock sector.

Poultry is the most viable livestock industry in Malaysia. Its productivity is the highest in the agricultural sector in Malaysia and close to international standards. Production is mainly undertaken by large commercial operations, which benefit from economies of scale and have strong links with the food processing industry.

The swine industry was one of the fastest growing industries prior to the Nipah virus outbreak in 1998, which resulted in a massive culling. The recovery in the swine industry has been slow since then. Domestically, pork is mainly consumed by ethnic Chinese, who account for around 25% of the population. The relatively small domestic market is insufficient to provide significant support for growth in the swine industry, while export opportunities have been limited by high production costs compared with those of neighbouring competing countries, such as Thailand.

The beef and dairy industries are small in Malaysia. There are many factors constraining growth in these industries. For example, the warm and humid climatic conditions are unfavourable for beef and milk production, especially with limited farm land available for pasture. In addition, the beef and dairy industries consist mainly of smallholders with relatively small herd sizes. As a result, it is difficult for the industries to achieve productivity gains and economies of scale, and to compete with imports.

3.5.4 Major trends in Agricultural Production

3.5.4.1 Growth in Agricultural Production Has Weakened

Growth in agricultural production in Malaysia has been declining, from an annual average of around 6.5% in the 1960s to 3% in the first half of the 2000s. Limited availability of arable land has been a major contributor to this slowdown in growth in agricultural production. The increase in agricultural land has slowed from an annual average of around 2.7% in the 1960s to an estimated rate of 1.61% in the first half of the 2000s. Strong competition for resources from the industrial sector has led to a significant decline in the share of agriculture in total employment, from around 26% in 1990 to 15% in 2006. Many male farm workers have migrated to urban areas and, as a result, women have become the major source of labour supply in many rural areas, providing around 75% of the labour force in areas such as Sabah (Masud and Paim 2004).

Malaysia focuses mainly on its industry and service sectors; its agricultural sector accounts for 7.2% of GDP. The agricultural sector employs 13% of the Malaysian labour force, or approximately 1.4 million people.

However, the sector continues to grow with agricultural output increasing nearly 3% annually; largely due to growth in livestock, fisheries, and palm oil. With the Ninth Malaysian Plan and Vision 2020, the Malaysian government hoped to reinvigorate the agriculture sector with policies to enhance the value chain by focusing on high value-added products and large-scale commercial farming, as well as technology, research and innovation, accreditation standards, and infrastructure. The Third National Agricultural Policy has also spelled out strategies for future development of agriculture sector. Similar to a number of other countries in the world, such as China and Indonesia, Malaysia has been focusing on domestic production and a national policy goal of “food self-sufficiency”. In order to sustain low inflation rates and maintain affordable food prices, the government enforces price regulations.

3.5.5 GHG Emissions from the Agriculture Sector

While the Agriculture sector related emissions do not constitute a large share of the country’s emissions, mitigation measures in the sector include irrigated rice water management (see Table 3.5.4), nitrogen fertilizer management and cattle manure management (see Table3.5.6).

Table 3.5.4: Area under flooded rice cultivation and methane emissions from flooded rice field

Water Management Regime		1990		1995		2000		2005		2009		2020 (Estimate)		2030 (Estimate)	
		Harvested Area (1000 ha)	CH ₄ Emissions (Gg)	Harvested Area (1000 ha)	CH ₄ Emissions (Gg)	Harvested Area (1000 ha)	CH ₄ Emissions (Gg)	Harvested Area (1000 ha)	CH ₄ Emissions (Gg)	Harvested Area (1000 ha)	CH ₄ Emissions (Gg)	Harvested Area (1000 ha)	CH ₄ Emissions (Gg)	Harvested Area (1000 ha)	CH ₄ Emissions (Gg)
Irrigated	Continuously Flooded	460.456	73.67	466.662	74.67	480.528	76.88	468.828	75.01	478.385	76.54	478.385	76.54	478.385	76.54
	Intermittently Flooded		0.00		0.00		0.00		0.00		0.00		0.00		0.00
			0.00		0.00		0.00		0.00		0.00		0.00		0.00
Rainfed	Flood Prone	65.151	8.34	62.596	8.01	67.137	8.59	63.537	8.13	65.07	8.33	65.07	8.33	65.07	8.33
	Drought Prone	65.151	4.17	62.596	4.01	67.137	4.30	63.537	4.07	65.07	4.16	65.07	4.16	65.07	4.16
Deep Water	Water Depth 50-100 cm		0.00		0.00		0.00		0.00		0.00		0.00		0.00
	Water Depth > 100 cm		0.00		0.00		0.00		0.00		0.00		0.00		0.00
Totals			86.18		86.68		89.77		87.21		89.04		89.04		89.04

Note: 1,000 Gg = 1 MtCO₂eq
Source: TERI Analysis, 2012

Most of the CH₄ emissions from rice cultivation (1,607 Gg CO₂ eq. or 85% in 2009) were from continuously flooded irrigated rice areas. Draining paddy fields can substantially reduce CH₄ emissions. For example, a single mid-season drainage will reduce emissions by 50%, and multiple drainage will reduce emissions by 80% (NC2, 2011). Alternatively water can be drained out earlier once the crop is mature. During off-rice seasons or periods of inter-cropping, water logging must be avoided and the soil must be kept as dry as possible. Water management infrastructure needs to be tailored towards alternating irrigating and draining once or several times during the growing and fallow seasons. With the proper set up of water control infrastructure and good water management especially in the main granary areas, it is estimated that GHG emissions from rice cultivation can be reduced by about 30% by 2015 compared to BAU levels. (NC2, 2011).

While the literature is scanty with regards to the effects of intermittent irrigation on paddy yield, Li et al. (1992) has used a computer simulation based on comprehensive biogeochemistry model, DNDC and has also conducted lysimeter experiments in Japan. In this study, three water management practices, continuous flooding, continuous flooding with mid-term drainage on day of year, and intermittent flooding with various flooding and drainage periods, were examined for a year with weather data acquired in central Japan. The results of the lysimeter experiments suggested that while intermittent irrigation schemes generally decreased the yield, a shorter interval of intermittent irrigation may reduce the net GHGs emission while it may maintain a certain degree of yield. On the contrary, the computer simulation, however, found a large increase in yield with increases in the interval of intermittent irrigation.

3.5.5.1 Field Burning of Agricultural Residues

Agricultural crop residue produced as a result of farming activities are being disposed in a variety of ways including the field burning of crop residues. On the agricultural crop residues in Malaysia rice straw is being mostly burned resulting in production of methane, carbon mono-oxide, nitrous oxide, and oxide of nitrogen.

Table 3.5.5 lists the carbon and nitrogen emissions from field burning of agricultural residues. With increase in productivity of rice over the years, the emissions from the burning of agricultural residues with rice straw as the main component is expected to increase.

Table 3.5.5: Emissions from field burning of agricultural residues (Gg)

	1990	1995	2000	2005	2009	2020	Total
CH ₄	0.90	1.04	1.02	1.11	1.17	1.72	2.40
CO	18.90	21.74	21.49	23.33	24.66	36.20	50.37
N ₂ O	0.02	0.02	0.02	0.03	0.03	0.04	0.06
NO _x	0.75	0.86	0.85	0.93	0.98	1.44	2.00

Note: 1,000 Gg = 1 MtCO₂eq

Source: TERI Analysis, 2012

At present, the most convenient way of straw disposal, both technically and economically, is burning. Soil incorporation of agricultural residues which at present is hardly being practised needs to be promoted and incentivised as a crop management practice so that the rice growers quit burning.

3.5.5.2 Nitrogenous Fertilizer Management

N₂O emissions from agricultural soil originate mainly from the added nitrogenous fertilizers contributing about 30% of total emissions for the agriculture sector. Emissions can be thus reduced by using alternative natural sources of nitrogen especially bio fertilizers or other beneficial soil microbes. Various types of microbes can fix atmospheric nitrogen (rhizobium-legume interaction) help in phosphorus mobilization; improve root structure for better absorption (mycorrhizae) thus supplying the plants with the nutrients and improving soil texture. The use of bio-fertilizers will reduce the heavy reliance on chemical fertilizers. In the long term, it can also increase the carbon sequestered in soil, thus increase the soil organic matter. Undertaking these measures can result in a reduction of 5-10% N₂O emissions by 2015 compared to BAU (NC2, 2011) with greater reductions expected by 2030.

3.5.5.3 Manure Management

Emissions from domestic livestock

Domestic livestock sector being the largest food industry in Malaysia in terms of output value contributes two major GHGs, methane and nitrous oxide. Table 3.5.6 shows the total methane emissions from enteric fermentation and manure management for year 1990, 1995, 2000, 2005, 2009, and projections for year 2020 and 2030. Cattle, because of its ruminant nature, has higher emission factor. Accordingly, the non-dairy/beef cattle are the main contributor to the emissions followed by swine. Emissions from the livestock sector is projected to increase from 69 Gg of methane in 1990 to 90 Gg in 2020, and 120 Gg in 2030 respectively.

Table 3.5.6: Methane emissions from domestic livestock enteric fermentation and manure management

Domestic livestock	Population	Total Annual Emissions from Domestic Livestock	Population	Total Annual Emissions from Domestic Livestock	Population	Total Annual Emissions from Domestic Livestock	Population	Total Annual Emissions from Domestic Livestock	Population	Total Annual Emissions from Domestic Livestock	Population Estimate	Total Annual Emissions from Domestic Livestock Estimate	Population Estimate	Total Annual Emissions from Domestic Livestock Estimate
	1990	(Gg)	1995	(Gg)	2000	(Gg)	2005	(Gg)	2009	(Gg)	2020	(Gg)	2030	(Gg)
Buffalo	205,163	12	164,838	10	142,042	8	133,232	8	130,617	8	52,445	3	26,139	2
Dairy cattle	33,386	3	35,800	3	36,695	2	29,690	2	33,835	3	32,034	3	31,102	3
Non-dairy/ beef cattle	634,334	29	680,200	31	697,197	35	751,626	39	856,569	39	929,932	43	1,075,631	49
Goat	331,278	2	282,460	1	237,634	2	287,670	2	506,136	3	549,886	3	775,577	4
Sheep	205,409	1	221,682	1	157,070	1	115,922	1	129,500	1	113,467	1	136,765	1
Swine	2,678,083	21	3,150,172	25	1,807,590	16	2,035,647	14	1,718,735	14	4,070,938	33	6,737,231	54
Poultry	57,000,000	1	112,000,000	3	123,650,000	4	174,694,000	5	208,333,000	5	259,604,000	6	321,231,000	7
Total		69		74		67		72		90				120

Note: 1,000 Gg = 1 MtCO₂eq

Emissions from Enteric Fermentation = (Emissions Factor for Enteric Fermentation x Population)/1000 ;

Emission factors for Enteric Fermentation (kg/ head/ year) - Buffalo (55), Dairy cattle (56), Beef cattle (44), Goat (5), Sheep (5), Swine (1), Poultry (0);

Emissions from Manure Management = (Emissions Factor for Manure Management x Population)/1000;

Emission factors for Manure Management (kg/ head/ year) - Buffalo (3), Dairy cattle (2), Beef cattle (2), Goat (0.22), Sheep (0.21), Swine (7), Poultry (0.023)

Total Annual Emissions from Domestic Livestock = (Emissions from Enteric Fermentation + Emissions from Manure Management)

Source: TERI Analysis, 2012, based on Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual.

In Malaysia, poultry and pig farming are being practised in a commercial way whereas, majority of buffalo, cattle, goat and sheep are owned by individual famers. Though there are some efforts in integrating palm oil cultivation and cattle rearing leading to sustainable farming, these efforts must be stepped up.

Emissions from Animal Waste Management System

Animal Waste Management System (AWMS) produces nitrous oxide. Table 3.5.7, 3.5.8, and 3.5.9 provide nitrogen excretions from different AWMS viz., anaerobic lagoons, solid storage and dry lots and, pasture range and paddock for different years. Swine is the main contributor to the anaerobic lagoons (around 70% in 2009) and the poultry industry for the solid storage and dry lot emissions (around 90% in 2009) whereas non-dairy cattle/beef cattle mainly contributes to pasture range and paddock emissions (around 64% in 2009). Table 3.5.7 shows the contribution of these livestock types is projected to grow further in 2020 and 2030.

Table 3.5.7: Nitrogen excretion for animal waste management system (anaerobic lagoons) (Gg N/yr)

Livestock Type	1990	1995	2000	2005	2009	2020 (Estimate)	2030 (Estimate)
Dairy cattle	0.60	0.64	0.66	0.53	0.60	0.57	0.55
Beef cattle	7.60	8.10	8.30	9.00	10.27	11.15	12.90
Sheep	-	-	-	-	-	-	-
Swine	40.70	47.88	27.47	30.94	26.12	61.87	102.40
Poultry	-	-	-	-	-	-	-
Total	48.91	56.68	36.50	40.49	37.01	73.61	115.87

Note: 1,000 Gg = 1 MtCO₂eq
Source: TERI Analysis, 2012

Table 3.5.8: Nitrogen excretion for animal waste management system (solid storage and dry lots) (Gg N/yr)

Livestock Type	1990	1995	2000	2005	2009	2020 (Estimate)	2030 (Estimate)
Dairy cattle	0.80	0.85	0.88	0.71	0.81	0.76	0.74
Beef cattle	7.61	8.16	8.36	9.01	10.27	11.15	12.90
Sheep	1.23	1.33	0.94	0.69	0.77	0.68	0.82
Swine	2.14	2.52	1.44	1.62	1.37	3.25	5.38
Poultry	32.49	63.84	70.48	99.57	118.74	147.97	183.10
Total	44.27	76.71	82.11	111.63	131.99	163.83	202.96

Note: 1,000 Gg = 1 MtCO₂eq
Source: TERI Analysis, 2012

Table 3.5.9: Nitrogen excretion for animal waste management system (pasture range and paddock) (Gg N/yr)

Livestock Type	1990	1995	2000	2005	2009	2020 (Estimate)	2030 (Estimate)
Dairy cattle	0.60	0.64	0.66	0.53	0.60	0.57	0.55
Beef cattle	10.14	10.88	11.15	12.02	13.70	14.87	17.21
Sheep	1.23	1.33	0.94	0.69	0.77	0.68	0.82
Swine	-	-	-	-	-	-	-
Poultry	1.71	3.36	3.70	5.24	6.24	7.78	9.63
Total	13.69	16.21	16.46	18.49	21.34	23.92	28.22

Note: 1,000 Gg = 1 MtCO₂eq

Source: TERI Analysis, 2012

Table 3.5.10 provides nitrous oxide emissions from different AWMS. There has been an increasing trend of total nitrous oxide emissions. While AWMS produces a total of 1.47 Gg nitrous oxide from solid storage and dry lots and anaerobic lagoon, it is projected to increase to 5.26 Gg and 6.56 Gg in 2020 and 2030, respectively.

Table 3.5.10: Nitrous oxide emissions from animal waste management system (Gg)

Animal Waste Management System (AWMS)	1990	1995	2000	2005	2009	2020 (Estimate)	2030 (Estimate)
Anaerobic lagoons	0.08	0.09	0.06	0.06	0.06	0.12	0.18
Liquid systems	-	-	-	-	-	-	-
Daily spread	-	-	-	-	-	-	-
Solid storage & drylot	1.39	2.41	2.58	3.51	4.15	5.15	6.38
Pasture range and paddock	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-
Total	1.47	2.50	2.64	3.57	4.21	5.26	6.56

Note: 1,000 Gg = 1 MtCO₂eq. Total annual emissions of N₂O (Mt) = (Nitrogen excretion (kg N/yr) X Emission factor for AWMS) [44/28]

Source: TERI Analysis, 2012

GHG emissions may increase proportionally to the number of livestock kept, and thus demand technological intervention. Technologies for reducing emissions from enteric fermentation are presently not economically feasible, especially when Malaysia is importing most of its concentrate feed. Collecting and storing livestock manure in lagoons or pools releases CH₄ from the anaerobic decomposition process. Aerobic composting of the manure can suppress CH₄ emissions. The addition of digester microbes can speed-up the decomposition process and reduce odour.

Further addition of beneficial microbes e.g. the nitrogen fixers and P-Solubilizers can turn the manure into more valuable bio-fertilizers. The use of composted manure in agricultural soils should be encouraged as it is a food source for soil microbes. Interactions between the manure and the microbes will increase the content of organic matter making the soil more fertile and sustainable for crop production while at the same time reducing GHG emissions both from manure decomposition and fertilizer usage. With the increase in prices of chemical fertilizers, the demand for composted manure is increasing, making it a good opportunity for farmers to earn some extra income. Adoption of this technology is easy and reduction of CH₄ emissions from cattle manure can be reduced by about 4% by 2015.

The next mitigation potential is biogas production from livestock such as beef feedlots and dairy farms as well as piggery wastewater. BAU practice in managing manure wastewater is to use open lagoons which generate GHG emissions. However, with proper facilities, the biogas or methane can be captured, thereby reducing GHG emissions. The captured methane can also be used as an energy source, further reducing GHG emissions from fossil fuel generated energy.

Usage of agrochemicals and chemical fertilizers is predominant in agriculture in Malaysia (Table 3.5.11). Increasing use of bio fertilizers and adopting integrated farming system approach comprising mixed crop and animal husbandry practices can effectively contribute to reduction in emissions from the sector as well as reaping economic gains.

Table 3.5.11: Use of agrochemicals in Malaysia (tonnes)

Item	2006	2007	2008
Insecticides	6,074.00	8,147.91	8,398.69
Organo-Phosphates	2,504.11	2,883.80	3,181.84
Carbamates	2,263.23	2,940.38	3,137.96
Insecticides			
Pyrethroids	458.89	1,170.54	869.92
Botanical Products & Biologicals	304.64	326.80	350.85
Other Insecticides	543.13	826.39	858.12
Herbicides	3,0427.41	34,835.22	4,1742.04
Urea derivates	639.12	600.94	911.98
Other Herbicides	2,6478.00	27,826.96	3,0174.40
Fungicides & Bactericides	2,483.77	3,173.73	3,986.68

Source: FAO, 2012

3.5.6 Carbon Dioxide Emissions under Business as Usual and Ambitious Scenarios

In the Business as Usual (BAU) Scenario, total methane and nitrous oxide emissions from the agriculture sector is estimated to be 3,795.96 Gg CO₂ eq. and 3,403.8 Gg CO₂ eq. in 2020, and 4,440.24 Gg CO₂ eq. and 3,813 Gg CO₂ eq. in 2030 respectively (Table 3.5.12).

Under ambitious scenario 1, practicing single drainage in paddy cultivation may lead to 50% reduction in methane emissions (44.52 Gg in 2020 and 2030). Similarly, by adopting improved nutrition through mechanical and chemical feed processing would reduce methane emission from livestock by 25% (67.5 Gg in 2020; 90 Gg in 2030). In CO₂ equivalent this may result in production of 5,792.34 Gg CO₂ eq. in 2020 and 6,688.32 Gg CO₂ eq. in 2030 respectively as compared to 7,199.76 Gg CO₂ eq. in 2020 in BAU scenario (Table 3.5.13).

Under ambitious scenario 2, practicing multiple drainage in paddy cultivation may lead to 80% reduction in methane emissions (17.8 Gg in 2020 and 2030). Similarly, by adopting improved nutrition through strategic supplementation would reduce methane emission from livestock by 75% (22.5 Gg in 2020; 30 Gg in 2030). In CO₂ equivalent this may result in production of 4,286.22 Gg CO₂ eq. in 2020 and 4,867.2 Gg CO₂ eq. in 2030 respectively as compared to 7,199.76 Gg CO₂ eq. in BAU scenario (Table 3.5.14).

Table 3.5.12: Business-As-Usual (BAU) scenario

GHG Source and Sink Categories		2020 (Gg)	CH ₄ (GWP=21) (Gg CO ₂ eq.) (2020)	N ₂ O (GWP=310) (Gg CO ₂ eq.) (2020)	Total (Gg CO ₂ eq.) (2020)	2030 (Gg)	CH ₄ (GWP=21) (Gg CO ₂ eq.) (2030)	N ₂ O (GWP=310) (Gg CO ₂ eq.) (2030)	Total (Gg CO ₂ eq.) (2030)
Enteric fermentation & manure management		90.00	1890.00	-	1890.00	120.00	2520.00	-	2520.00
Animal Waste Management System		5.26	-	1630.60	1630.60	6.56	-	2033.60	2033.60
Rice Cultivation		89.04	1869.84	-	1869.84	89.04	1869.84	-	1869.84
Field burning of agricultural residues	CH ₄	1.72	36.12	-	36.12	2.40	50.40	-	50.40
	N ₂ O	0.04	-	12.40	12.40	0.06	-	18.60	18.60
Agricultural Soils		5.68	-	1760.80	1760.80	5.68	-	1760.80	1760.80
Total			3795.96	3403.8	7199.76		4440.24	3813.00	8253.24

Note: 1,000 Gg = 1 MtCO₂eq.

GWP= Global warming potential

Source: TERI Analysis, 2012

Table 3.5.13: Ambitious scenario 1

GHG Source and Sink Categories		2020 (Gg)	CH ₄ (GWP=21) (Gg CO ₂ eq.) (2020)	N ₂ O (GWP=310) (Gg CO ₂ eq.) (2020)	Total (Gg CO ₂ eq.) (2020)	2030 (Gg)	CH ₄ (GWP=21) (Gg CO ₂ eq.) (2030)	N ₂ O (GWP=310) (Gg CO ₂ eq.) (2030)	Total (Gg CO ₂ eq.) (2030)
Enteric fermentation & manure management		67.50	1417.50	-	1417.50	90.00	1890.00	-	1890.00
Animal Waste Management System		5.26	-	1630.60	1630.60	6.56	-	2033.60	2033.60
Rice Cultivation		44.52	934.92	-	934.92	44.52	934.92	-	934.92
Field burning of agricultural residues	CH ₄	1.72	36.12	-	36.12	2.40	50.40	-	50.40
	N ₂ O	0.04	-	12.40	12.40	0.06	-	18.60	18.60
Agricultural Soils		5.68	-	1760.80	1760.80	5.68	-	1760.80	1760.80
Total			2388.54	3403.80	5792.34		2875.32	3813.00	6688.32

Note: 1,000 Gg = 1 MtCO₂ eq.

GWP= Global warming potential

Source: TERI Analysis, 2012

Table 3.5.14: Ambitious scenario 2

GHG Source and Sink Categories		2020 (Gg)	CH ₄ (GWP=21) (Gg CO ₂ eq.) (2020)	N ₂ O (GWP=310) (Gg CO ₂ eq.) (2020)	Total (Gg CO ₂ eq.) (2020)	2030 (Gg)	CH ₄ (GWP*=21) (Gg CO ₂ eq.) (2030)	N ₂ O (GWP=310) (Gg CO ₂ eq.) (2030)	Total (Gg CO ₂ eq.) (2030)
Enteric fermentation & manure management		22.50	472.50	-	472.50	30.00	630.00	-	630.00
Animal Waste Management System		5.26	-	1630.60	1630.60	6.56	-	2033.60	2033.60
Rice Cultivation		17.80	373.80	-	373.80	17.80	373.80	-	373.80
Field burning of agricultural residues	CH ₄	1.72	36.12	-	36.12	2.40	50.40	-	50.40
	N ₂ O	0.04	-	12.40	12.40	0.06	-	18.60	18.60
Agricultural Soils		5.68	-	1760.80	1760.80	5.68	-	1760.80	1760.80
Total			882.42	3403.80	4286.22		1054.20	3813.00	4867.20

Note: 1,000 Gg = 1 MtCO₂eq.

GWP= Global warming potential

Source: TERI Analysis, 2012

3.5.7 Key Findings and the Way Forward

Overall, the agriculture sector is not a high ranking key source of GHG emissions in Malaysia. This is mainly because rice cultivation and animal husbandry activities are relatively small and did not expand much in the years. The agriculture sector in Malaysia contributes two major GHGs - methane and nitrous oxide respectively. Methane is largely being contributed by flooded rice cultivation followed by domestic livestock enteric fermentation, manure management and burning of agricultural crop residues, particularly rice straw. Although the contribution of nitrous oxide is less, because of its higher global warming potential and its harmful effects on ozone layerable, its effect on the environment is quite substantial.

The analysis of mitigation potential in the agriculture sector, under the BAU scenario indicates that GHG emissions would increase from 7.19 MtCO₂ eq. in 2020 to 8.25MtCO₂ eq. in 2030. In the ambitious scenario 1, the emissions would reduce to 5.79 MtCO₂ eq. in 2020 to 6.69 MtCO₂ eq. in 2030. The savings in GHG emissions between the BAU and ambitious scenario 1 for 2020 is 1.40 MtCO₂ eq. This could be achieved by practicing single drainage in paddy cultivation leading to 50% reduction in methane emissions and by adopting improved nutrition through mechanical and chemical feed processing resulting in reduction in methane emission from livestock by 25%. Similarly, the savings in GHG emissions measuring 2.91 MtCO₂ eq. between the BAU and ambitious scenario 2 for 2020 could be achieved by practicing multiple drainage in paddy cultivation, resulting in 80% reduction in methane emissions and by adopting improved nutrition through strategic supplementation enabling reduction in methane emission from livestock by 75%.

A sustainable farming system approach would be the key for future growth of agriculture in Malaysia. Agriculture being the main consumer of water among all sectors, the need to improve agricultural productivity in rice would lead to greater pressure on water resources. Efficient water management in paddy cultivation would be essential for controlling methane emissions. Irrigation efficiencies are low varying from 40% to 70%, mainly in the non-granary areas due to lower level of management in comparison to the granary areas where the irrigation structure and the institutional set up are more robust. Similarly, improving or modifying farming practices, such as alternate wetting and drying in rice fields which leads to lower emissions, and introduction of short duration paddy varieties would also lead to efficient water demand management. The actions for emissions reductions in the agriculture sector in paddy cultivation are listed in Table 3.5.15.

Table 3.5.15: Emission reduction options in paddy cultivation

Strategy	Basic Working Mechanism	Remarks
Application of ammonium fertilizers in the reduced zone	Ammonium sulphate reduces CH ₄ emissions by 63%. In reduced zone, it will not affect CH ₄ oxidation and there will be negligible nitrification and denitrification to produce N ₂ O	Ammonium and urea can be deep-placed at planting and once later, through mud ball placement at 10–12 cm below ground at the base of the seedlings in row-transplanted rice
Application of N in splits at critical growth stages	In initial stages, low doses of N are advisable as N uptake by rice is low	Split application should be done on dry field and no immediate irrigation should follow to reduce wastage of fertilizer
Addition of nitrification inhibitors (NI) with urea and ammonium fertilizers	NI will minimize N ₂ O emission via nitrification directly and denitrification indirectly and may inhibit CH ₄ formation also	DCD, neem-coated urea, ECC, nitrapyrin, etc. may be applied along with fertilizers
Application of foliar urea-N in water-logged conditions	Foliar-N spray may reduce N ₂ O emissions from soil and reduced methane fluxes by 45, 60 and 20% in ammonium sulphate, ammonium chloride and urea broadcasted plots, respectively	Concentration of urea solution should be carefully chosen to prevent foliar damage
Mid-season drainage should be practiced when it does not coincide with high soil ammonium	Mid-season drainage reduces CH ₄ formation and enhances CH ₄ oxidation but high soil ammonium may increase N ₂ O emission via nitrification	To prevent NH ₄ ⁺ accumulation, urea and ammonium should be applied in splits and soil ammonium should be regularly monitored. Mid-season drainage should not reduce yield
Irrigation by good-quality water	Good quality irrigation water will help maintain an oxidized zone in soil helping CH ₄ oxidation	Wastewater irrigation may considerably increase CH ₄ and N ₂ O emissions and so should be avoided
Plant population should be optimum	Nutrient uptake will be good and N ₂ O and CH ₄ emissions through plants will be low	Nutrient and water management and cultural practices can be practiced with a greater ease
Rice varieties with low gas transport, low exudate production and high harvest index are preferable	These varieties will control emission of both the gases	Many rice varieties have not been tested for their gas transport potentials. Sometimes, seeds of the desired varieties may not be available
Application of slow-release N, especially S and rock phosphate-coated urea	Neem coated, shellac coated, wax coated, nimin coated, etc. can also be used. Neem-based products can also act as nitrification inhibitors	These products can be indigenously produced with locally available materials

3.5.7.1 Managing Methane Emissions from Paddy Cultivation

Continuously flooded irrigated rice areas contribute most of the methane emissions from rice cultivation. Methane emission from a given area under paddy cultivation is contingent upon water regimes (before and during cultivation period), agronomic characteristics (the number and duration of crops grown, fertilizer application, organic and inorganic soil amendments, soil type, temperature, and rice cultivar). It has been observed that a single mid-season drainage and reduces emission by 50% whereas, in case of multiple drainage, an 80% reduction in methane emissions could be achieved (see Box 3.5.1). Further, when the crop attains maturity the standing water in the field should be drained out. Also it is important to ensure that the field should be kept dry when possible like during the off-rice season. In the above context it is important to create water management infrastructures which could regulate and control water inflow and outflow from the paddy field as per the requirement. With proper set up of water control infrastructures and good water management especially in the main granary areas the GHG emission from rice cultivation can be reduced.

Box 3.5.1: Mitigation within one irrigation system in the Philippines

Bohol Island, one of the largest rice-growing areas in the Visayas region of the Philippines, has experienced declining productivity and income from existing irrigation systems. The problem has been aggravated by the practice of unequal water distribution and unnecessary water use by farmers who insist on continuous flooding to irrigate their rice crop. The construction of a new dam was accompanied by a plan to implement a water-saving technology called alternate wetting and drying (AWD), developed by IRRI in cooperation with national research institutes. Visible success of AWD in pilot farms and specific training programmes for farmers has helped to dispel the widespread misperception of possible yield losses in non-flooded rice fields. Adoption of AWD facilitated improved use of irrigation water and increased rice productivity. Using the methodology of the Intergovernmental Panel on Climate Change (IPCC) modification of water regime also can reduce methane emissions by almost 50 per cent as compared to rice produced under continuous flooding. The Bohol case is an example of new technologies that increase the income of poor farmers while decreasing GHG emissions.

Source: http://www.ifpri.org/sites/default/files/publications/focus16_03.pdf

Management of emissions resulting from nitrogenous fertilizer applications

The nitrous oxide emission from agricultural soil originates mainly from the added nitrogenous fertilizer. Emissions can thus be reduced by using alternative natural sources of nitrogen especially the biofertilizers or the soil microbes. Various types of bacteria can fix atmospheric nitrogen and make it available to plants. These bacteria exist in the soil as free living or in symbiotic relationship with plants. Mycorrhizal fungi live symbiotically around plant roots and act as nutrient transporters to the plant roots via their foraging hypha from distances not accessed by the plant roots.

Further, they mobilize the non-available form of nutrients, especially phosphorous, thus making it available to the plants. Some microbes also solubilize the soil mineral or fixed phosphorous, produce plant biostimulant and act as biocontrol agents. The leguminous plants are known to form symbiotic association with *Rhizobium* and root nodules (factories for fixation of atmospheric nitrogen) are formed.

Biofertilizers are mainly produced locally. The use of biofertilizers will reduce the heavy reliance on chemical fertilizers which in long term will increase the carbon sequestered in the soil and thus the soil organic matter. The level of soil organic matter is proportional to soil cation exchange capacity (CEC) and reflects the soil fertility in general. The desired minimum level of soil organic matter is about 2% and many Malaysian agricultural soils are far below this. Biofertilizers are however sensitive to extreme climatic conditions and agricultural chemicals and are relatively difficult to handle, thus their adoption will need massive awareness programme. Also, their shelf life is short, thus demanding efficient and timely delivery mechanism.

Box 3.5.2: Low carbon agriculture in China – reducing inefficiencies in the production and use of nitrogen fertilizer

China and the UK launched a three year joint project in April 2009 focusing on synthetic nitrogen fertilizer use for crops, and linkages between crop and livestock production and the potential for improved manure use and organic fertilizer production. The manufacture and use of synthetic nitrogen fertilizer is estimated to account for some 9-15% of China's total greenhouse gas (GHG) emissions as well as contributing to acid rain, water pollution, the increasing frequency of red tides and reduced farm incomes. One of the key actions to achieve low carbon agriculture in China is to reduce inefficiencies in the production and use of nitrogen fertilizer. Trials show that nitrogen use could be cut by at least 30% with no loss of crop production, achieving savings of 2-3% in China's total GHG emissions as well as boosting net farm incomes and reducing pollution. The global benefits would be equally significant as China accounts for some 30% world N fertilizer production and 27% of global N fertilizer use.

Source: Building the foundations for sustainable nutrient management. Published by UNEP on behalf of the Global Partnership on Nutrient Management (GPNM), Kenya, 2010

3.5.7.2 Methane Emission Reduction in the Livestock Sector

The amount of livestock methane that is released depends on the type, age, and weight of the animal, the quality and quantity of the feed, and the energy expenditure of the animal.

Following measures could be adopted to reduce methane emission - improved feeding practices e.g. increase concentrates feed, adding additives e.g. oil to diet, and improved pasture quality; specific agents and dietary additives to suppress methanogenesis e.g. halogenated compound, tannins, saponins, essential oil; improved productivity through breeding and better management practices.

- i *Improved Nutrition through Mechanical and Chemical Feed Processing:* Improved nutrition reduces methane emissions per unit product by enhancing animal performance, including weight gain, milk production, work production, and reproductive performance. Mechanical and chemical feed processing options include wrapping and preserving rice straw to enhance digestibility, chopping straw to enhance animal intake, and alkali treatment of low digestible straws to enhance digestibility. These options are applicable to accessible ruminant animals with limited or poor quality feed, and may decrease methane emissions per unit product on the order of 10 to 25 percent (assuming feed digestibility is increased by 5 percent), depending on animal management practices.
- ii *Improved Nutrition through Strategic Supplementation:* Strategic supplementation provides critical nutrients such as nitrogen and important minerals to animals on low quality feeds. Additionally, it may include providing microbial and/or bypass protein to the animal. Methane emissions per unit product may be reduced by 25 to 75 percent due to substantial increases in animal production efficiency, depending on animal management practices. In particular, applying molasses/urea multi nutrient blocks (MNBs) and bypass protein techniques in tropical areas with chronic feed constraints can produce emissions reductions per unit product near the high end of the range. The use of chemicals (ionophores) and defaunation are also possible options, though further efforts to develop better agents and to demonstrate practical methods of defaunation are necessary.
- iii *Production Enhancing Agents:* Certain agents can act directly to improve productivity. These agents are generally most applicable to large-scale commercial systems with well-developed markets. Emissions reductions per unit product of 5 to 15 percent have been demonstrated. Additional reductions may be achieved by shifts in rumen microbial patterns. Options include the use of bovine somatotropin (BST) and anabolic steroids.
- iv *Improved Production through Improved Genetics:* Genetics is the limiting factors mainly in intensive production systems. Continued improvements in genetic stock through breeding of superior parents will increase productivity, and thereby reduce methane emissions per unit of milk production. Emissions reductions from these options remain to be quantified.
- v *Improved Production Efficiency through Improved Reproduction:* Large portions of the herd of large ruminants are maintained for the purpose of producing offspring. Methane emissions per unit product can be significantly reduced if reproductive efficiency is increased and fewer animals are required to provide the desired number of offspring. Options such as artificial insemination, twinning, and embryo transplants address reproduction directly. The nutritional options described above can also improve reproduction. Further, through these techniques, the livestock breed can be improved significantly with the objective of increasing meat and milk productivity.

GHG emissions will increase proportional to the number of livestock kept. Technologies on reducing emission from enteric fermentation are presently not economically feasible especially when Malaysia is importing most of the concentrate feed.

3.5.7.3 Manure Management for N₂O and CH₄ reduction

During storage of manure, some manure nitrogen is converted to N₂O. CH₄ is produced from the decomposition of manure under anaerobic conditions. These conditions often occur when large numbers of animals are managed in a confined area (e.g., dairy farms, beef feedlots, and swine and poultry farms), where manure is typically stored in large piles or disposed of in lagoons.

Collecting and storing cattle manure in lagoons or pools releases CH₄ from the anaerobic decomposition process. Aerobic composting of the manure can suppress CH₄ emission. This is especially important when cattle are kept under confinement in the feedlot system or for dairy production where manures are normally flushed into retention pond. For aerobic composting the manure can be collected and stored in the solid form. Addition of digester microbes can speed-up the decomposition process and reduce odour. Further, addition of beneficial microbes, e.g. the nitrogen fixers and phosphorus solubilizers, will turn it to more valuable biofertilizers.

The use of composted manures in agricultural soils should be encouraged as it is a food source for the soil microbes, the manures and the microbes interactions will increase the soil organic matter content making the soil more fertile and more sustainable for crop production.

With the increase in prices of chemical fertilizers, the demand for composted manure is increasing making it a good opportunity for farmers to earn extra income from it. Adoption of this technology will be easy and reduction of CH₄ emission from cattle manure can be reduced by 4% by 2015.

Box 3.5.3: Hybrid Technology Biodigester in Vietnam

Recently, together with many Vietnamese NGOs, The Center for Rural Communities Research & Development (CCRD) belonging to the Vietnam Gardening Association(VACVINA)) is very successful in the application of biogas technology and biofertilizer, which show high effectiveness in emission reduction. VACVINA's Hybrid Technology Biodigester with automatic scum control.

Biogas application is a consolidated solution with multi-objectives to reduce greenhouse gas emission. In particular: reduce emission more than 5.4 tonnes of CO₂/ year/1 biogas digester. Since 2002, there have been up to over 10,000 biodigesters, which contribute emission reduction by 54,000 tonnes. The production and use of bio- fertilizer, make full use of slurry from biogas digester can discourage the use of chemical fertilizer, increase plant productivity. CCRD has been supported in production of 2,000 tonnes of bio- fertilizer; reduce emission about 200 tonnes of NPK/year.

Source: Le Thi Xuan Thu (2008). Country Report on Bio-slurry utilization in Vietnam, Biogas Project Division, The Biogas Programme for the Animal Husbandry Sector of Vietnam

i Livestock and manure management

Estimations of costs and mitigation potentials in this category vary significantly between countries and world regions (cp. USEPA 2006 and Povellato et al. 2007). Table 3.5.16 provides an overview on different estimations of economic potentials at different CO₂ prices between 0 and 200 USD/CO₂ eq.

Table 3.5.16 indicates that a large share of the mitigation potential is in the low cost range of less than 30 USD/tCO₂ eq. Measures with very high costs do not substantially increase mitigation potentials. There seems to be substantial mitigation potential at zero or even negative costs. In fact, MAC curves of some mitigation strategies become negative if the mitigation measures lead to increased efficiency in meat and milk production (DeAngelo et al. 2006, Weiske et al. 2006).

Table 3.5.16: Livestock and manure – projected baseline emissions and economic mitigation potentials at different CO₂ prices

Year	Base-line in MtCO ₂ eq.	Economic mitigation potentials in MtCO ₂ eq.							Source
		Value of CO ₂ in USD/tCO ₂ eq.							
		0	15	30	45	60	100	200	
2010	567	29	-	-	-	-	-	31	De Angelo et al. 2006
2020	2,867	83	126	158	175	192	-	-	USEPA 2006
2030	-	-	-	-	-	-	210	-	Smith et al. 2008

ii Rice management

As in the case of livestock and manure management, the feasibility and the costs of rice mitigation strategies depend on regional characteristics (Povellato et al. 2007). Table 3.5.17 provides an overview of mitigation potentials related to rice management.

In the case of rice management, the largest share of mitigation potentials seems to be in the low cost range of less than 15 USD/tCO₂ eq. Potentials hardly increase with higher costs. Again, De Angelo et al. (2006) assume much lower potentials than the other mentioned sources. Yet, since they also assume lower baseline emissions, the relative shares are comparable.

Table 3.5.17: Rice - projected baseline emissions and economic mitigation potentials at different CO₂ prices

Year	Baseline in MtCO ₂ eq.	Economic mitigation potentials in MtCO ₂ eq.							Source
		Value of CO ₂ in USD/tCO ₂ eq.							
		0	15	30	45	60	100	200	
2010	185	19	-	-	-	-	-	56	De Angelo et al. 2006
2020	1,026	114	235	238	259	259	-	-	USEPA 2006
2030	-	-	-	-	-	-	230	-	Smith et al. 2008

The estimated CO₂ reduction potential for 2020 is as follows: 0.473 MtCO₂ eq. from enteric fermentation and manual management, and from rice cultivation is 0.935 MtCO₂ eq, thereby having a potential reduction of a total 1.408 MtCO₂ eq.

Similarly, the estimated CO₂ reduction potential for 2030 is as follows: 0.630 MtCO₂ eq. from enteric fermentation and manual management, and from rice cultivation is 0.935 MtCO₂ eq, thereby having a potential reduction of a total 1.565 MtCO₂ eq.

3.5.8 Action Plan for Implementation

Agriculture practices followed in Malaysia are fairly advanced and are of higher standards. However, there are some scopes of improvement in increasing productivity in a sustainable manner. Without compromising on food security, the pressure on arable land can be significantly reduced and land can be used for other activities such as forestry leading to higher CO₂ sequestration, etc. Since rainfall is spread over the year and temperatures are conducive for the plant growth, Malaysia must go for multiple cropping, especially in areas where irrigation is available. To ensure sustainable agriculture, use of organic products (biofertilizers and biopesticides) must be encouraged. This will not only reduce imports of fertilizers but will also help in reducing GHG emissions. Investments in developing new varieties of major crops will help in achieving higher yields, efficient use of nutrients and water and nutritionally better varieties. Farm mechanization may further be enhanced through innovative machines, thus reduce pressures on scarce human resources.

Malaysia must invest in research programmes based on conventional and molecular tools (biotechnologies) for developing better varieties. Further, an integrated farming system approach may lead to socio–economics benefits in terms of increased food production, increased net income, improved family productivity and improved farmer's living conditions.

The country must invest on livestock with the increasing demand and country's commitment for achieving self-sufficiency; however, one must be sensitive towards its possible impact on GHG. Programmes must be initiated to improve livestock (by application of biotechnologies) as well as its feed (less of methane generation).

The focus has to shift from only increasing the productivity for self-sufficiency to attaining self-sufficiency in a sustainable manner. To achieve this, several programmes must be developed and implemented immediately. Broadly, they can be classified as under:

Short term

- Improved crop management practices (including water efficiency in rice)
- Use of biofertilizers and biopesticides
- Increase cropping cycles, especially in irrigated paddy areas
- Initiate research on animal feed
- Initiate research on developing better plant varieties, both by conventional and bio technological tools.
- Initiate research on farm machinery to further reduce labour requirements in the field.
- Initiate research on livestock improvement and livestock feed.

Medium term

- Large scale adaptation of cleaner and more sustainable practices for agriculture
- Establishment of commercial biofertilizer and biopesticides units
- Adaptation of practices for improving breed of livestock
- Ensuring availability of improved feed

Long term

- Adaptation of crop varieties development which are:
 - High yielding
 - Varieties that utilizes resources (water and nutrients) more efficiently
- Large scale adaptation of improved varieties of livestock and improved feed
- Greater degree of farm mechanization
- Adopting multiple cropping pattern

3.6 Energy Consumption

3.6.1 Overview of End Use Energy Demand

Total end use energy consumption in Malaysia has increased by more than 6.5 times from 6.4 Mtoe in 1980 to 41.5 Mtoe in 2010. This reflects an annual growth of 6% over the period (Figure 3.6.1). There has been a more or less continuous increase in end use energy consumption from 1980 to 2008 (except for a minor dip in 1997). In 2009, energy consumption decreased to 40.8 Mtoe from 44.9 Mtoe in 2008 (9% reduction from the previous year) which could be possibly attributed to the slowdown in the economy.

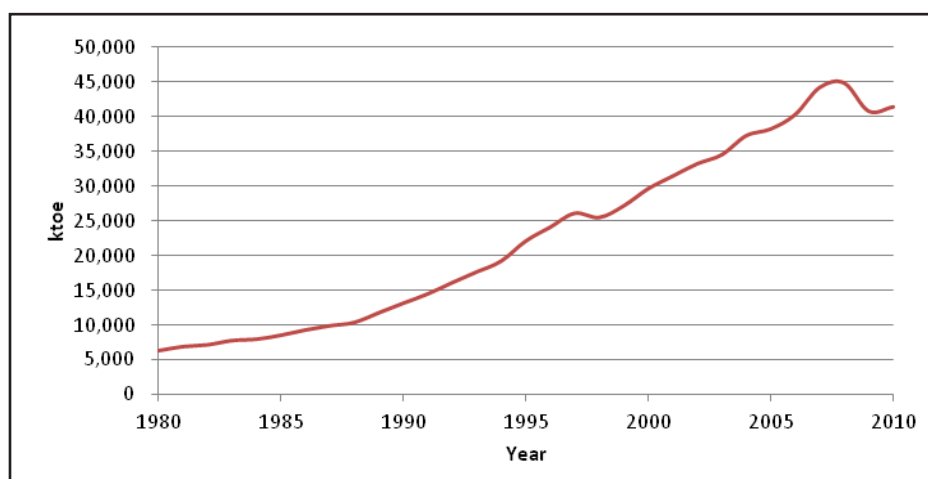


Figure 3.6.1: Final energy consumption (1980-2010)

Source: NEB, 2010

On the demand side, the sectors that consume energy can broadly be classified as residential, commercial, industrial, transport, agriculture and non-energy use. Figure 3.6.2 represents the sector-wise energy consumption in Malaysia. Apparently, the share of each of the sectors in total energy consumption has remained largely unchanged over the past three decades. Industrial and transport sectors are the major end-use consumption sectors accounting for more than 70% of the total energy use (Figure 3.6.3).

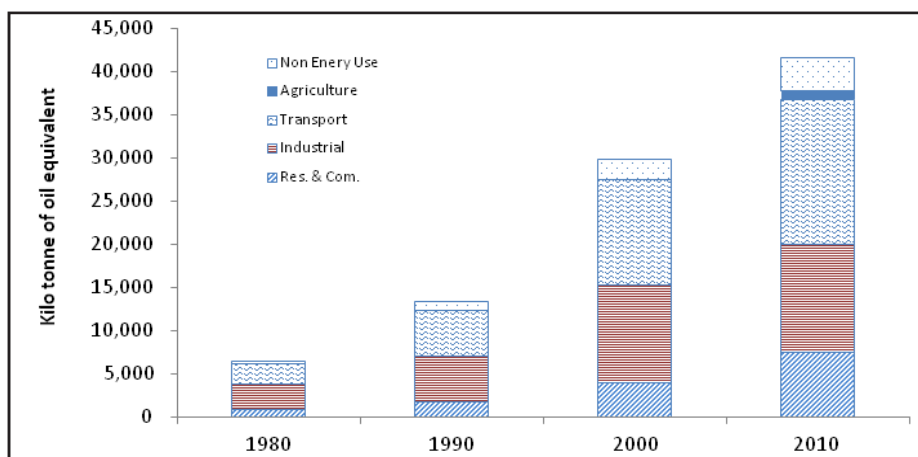


Figure 3.6.2: End use energy consumption by sector (1980-2010)
Source: NEB, 2010

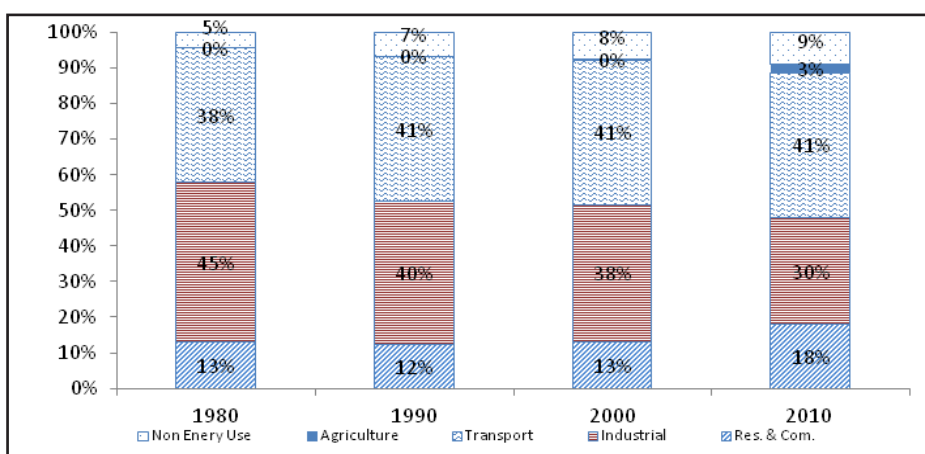


Figure 3.6.3: Sectoral contribution to end use energy consumption (1980-2010)
Source: NEB, 2010

Regarding the importance of undertaking a detailed assessment of likely changes in activity level and associated energy requirements this study examines the growth in energy in each of the demand sectors, examine the end-uses responsible for this growth and the possibility of transitions in the technologies and usage patterns associated with these end-uses. The following sections 3.7 to 3.9 examine each of the demand sectors in detail.

Given that opportunities for change exist not only across end use demand sectors but also right through the entire fuel supply chain as well (fuel extraction to transport, conversion and end use) there are several trade off and substitutions possibilities across the entire energy sector. Therefore, examining the energy sector holistically with an integrated

approach becomes crucial. Accordingly, the estimated useful energy demands in each of the sectors are included in the MARKAL model for undertaking an integrated analysis of the energy sector from the energy and emissions viewpoint.

Scenarios developed within each of the energy demand sectors are evaluated through the MARKAL mode (which considers an integrated assessment of fuel supply and energy demand for Malaysia over a 30 year period) and the overall assessment of energy and emission saving possibility is derived from this model and presented later on in this report (Section 3.11).

Data and assumptions used for the model have been drawn from secondary data/statistics of various departments, sourced from reports, based on the discussions with local experts and/or drawn out on the basis of international data. All data, however, was validated for the model base year to calibrate the model, for which assumptions were carefully selected/ modified as discussed in each of the sectors under the mitigation assessment.

It must be noted that while models such as the MARKAL model used in this study, serve a useful purpose in providing an integrated assessment of the energy sector, the results and findings should be viewed as directional rather than relying on the exact numbers or shares for fuel or technology use in the future.

3.7 Transport Sector

3.7.1 Introduction

3.7.1.1 Overview of Transport Sector in Malaysia

The transport sector is one of the largest energy consuming sectors in Malaysia. Fuel consumption has increased rapidly in the transport sector as indicated in Figure 3.7.1, growing from around 2.4 Mtoe in 1980 to 16.8 Mtoe in 2010 at a compounded annual growth rate of around 6.7%.

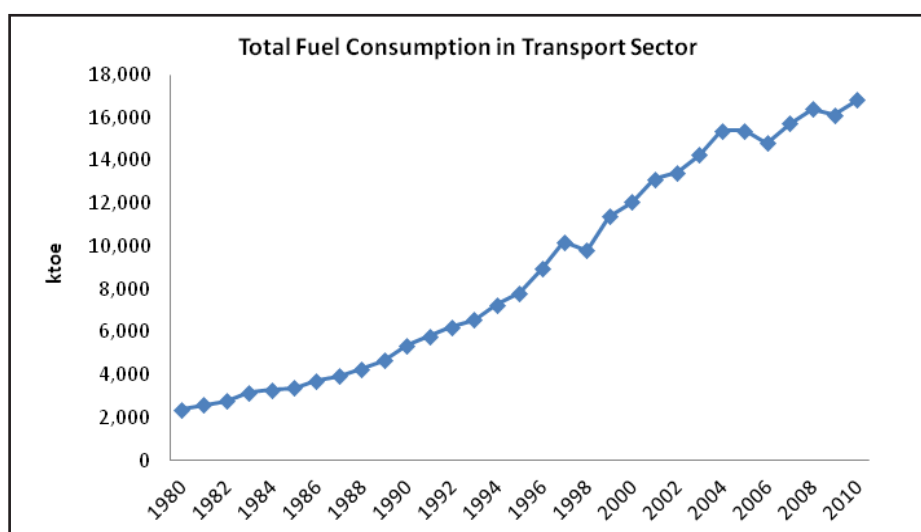


Figure 3.7.1: Energy consumption in the transport sector

Source: NEB, 2010

Both the passenger and tonne kilometres have been increasing over the years. The total passenger movement increased from 451.36 billion in 2000 to 860.20 billion in 2010. The total tonne kilometres increased from 80.92 billion in 2000 to 120.13 billion in 2010⁷³.

Figure 3.7.2 and Figure 3.7.3 shows the share of various modes in total passenger movement and the share of various modes in total freight movement respectively.

⁷³ The total passenger movement has been calculated by taking into account passenger movement by road, rail, and other rail based modes and air since the data on passenger movement by maritime was not available. Average distance travelled per passenger in case of other rail based modes is assumed to be 50% of the length of the rail line and accordingly passenger kilometres have been calculated. The passenger kilometres by air have been calculated assuming average distance travelled per passenger to be 2,065 km. Also, the freight movement has been calculated by considering tonne kilometres by rail, road and air since the data on freight carried by maritime was in terms of tonne carried and not tonne kilometre. In case of road transport, assumptions are taken on the average distance travelled and occupancy /load factor and passenger and tonne kilometres have been calculated accordingly.

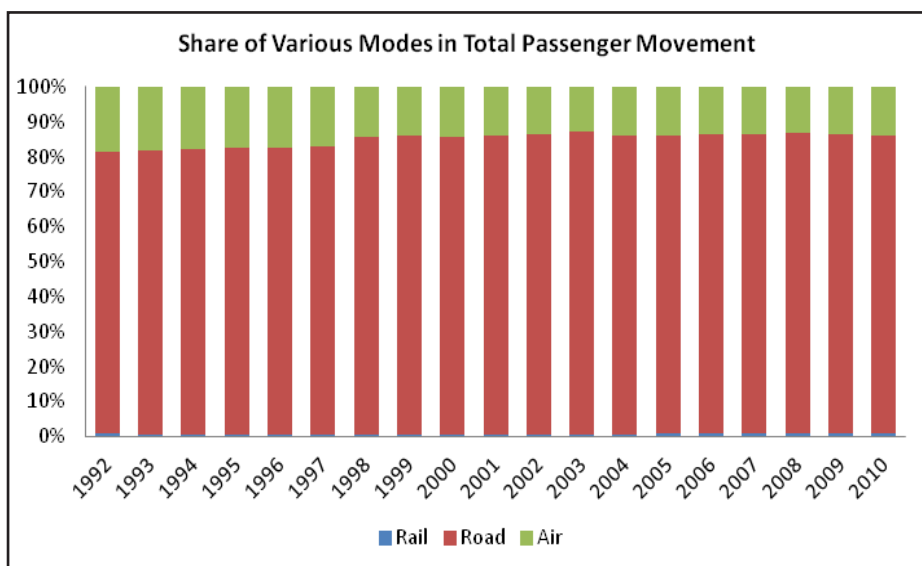


Figure 3.7.2: Share of various modes in total passenger movement
Source : TERI estimates adapted from MoT 2010, KTMB 2011

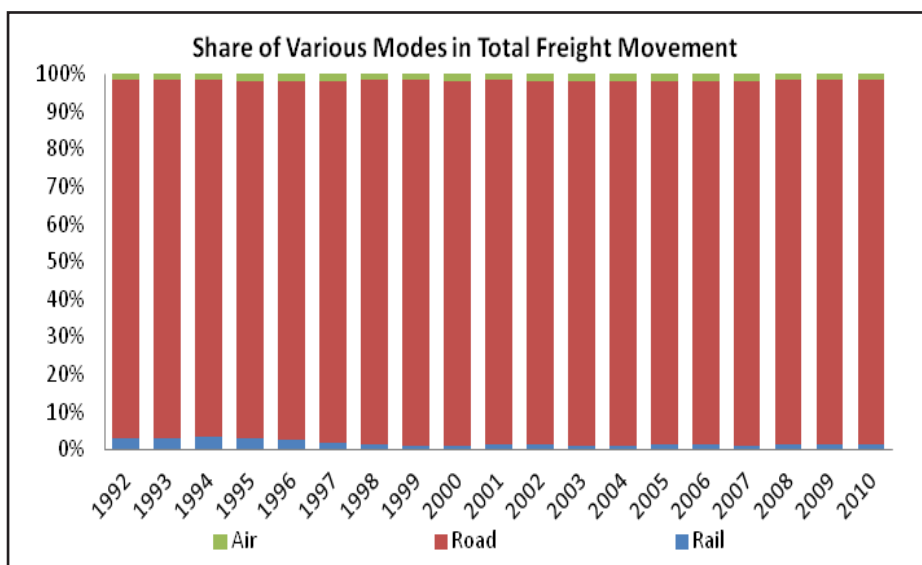


Figure 3.7.3: Share of various modes in total freight movement
Source : TERI estimates adapted from MoT 2010, KTMB 2011

As indicated, road based passenger movement accounted for nearly 85% of the total passenger movement and 97% of the total freight movement in 2010.

Figure 3.7.4 shows the passenger kilometres by various modes of transport in the last few years. While road based passenger kilometres have increased at a rate of 6.7% between 2000 and 2010, a lot of fluctuations are observed in the rail based passenger movement in the last few years.

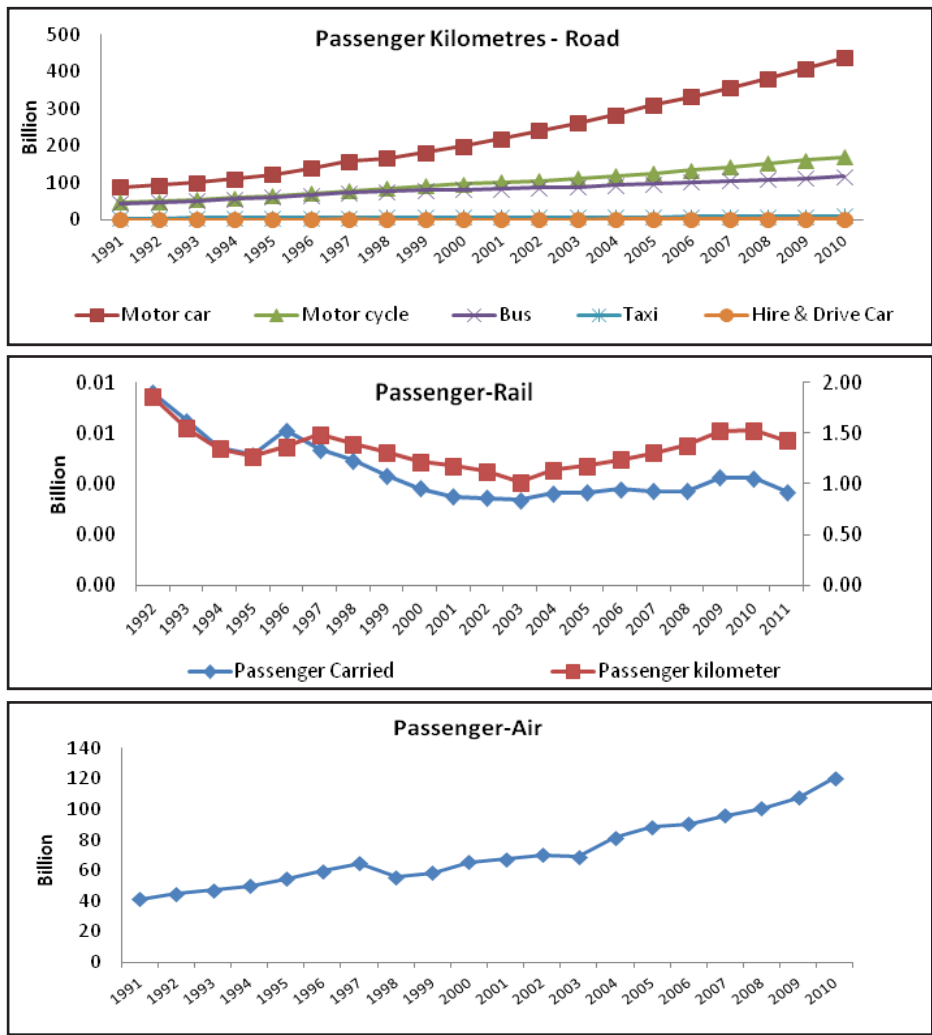


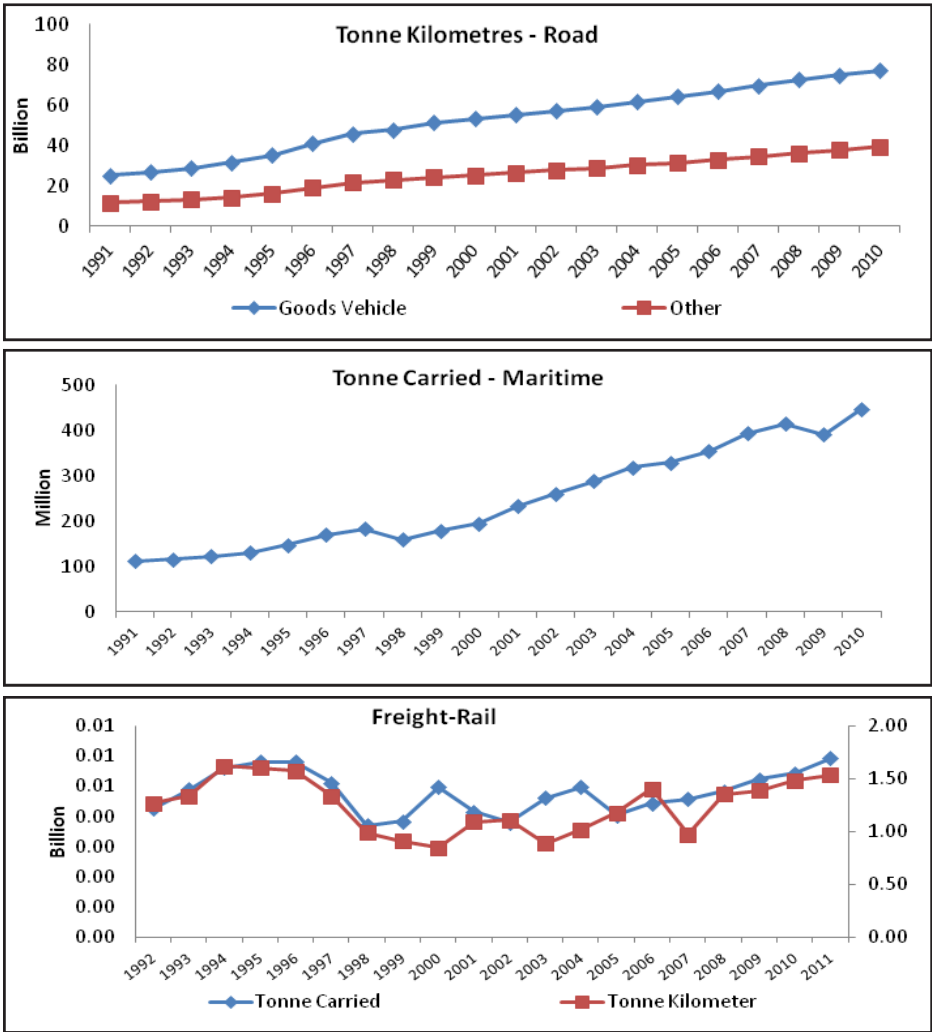
Figure 3.7.4: Passenger movement by various modes ⁷⁴

Source: TERI estimates adapted from MoT 2010, KTMB 2011

⁷⁴ Passenger Kilometre – Road: Calculated on the basis of assumption for mileage and occupancy. (Source for assumption on mileage: PTM, 2005; Source for assumption on occupancy: UM Report, 2005; Source for number of vehicles for 2009 and 2010: Ministry of Transport, Malaysia, 2010).

In the case of air transport (including both domestic and international passengers), the passenger kilometres has increased from nearly 41 billion in 1991 to more than 120 billion in 2010⁷⁵, with passenger kilometres increasing at a compounded annual growth rate of 6.31% in the last ten years.

Figure 3.7.5 (below) shows the tonne kilometres by various modes of transport in the last few years.



⁷⁵ Passenger Kilometre – Road: Calculated on the basis of assumption for mileage and occupancy. (Source for assumption on mileage: PTM, 2005; Source for assumption on occupancy: UM Report, 2005; Source for number of vehicles for 2009 and 2010: Ministry of Transport, Malaysia, 2010).

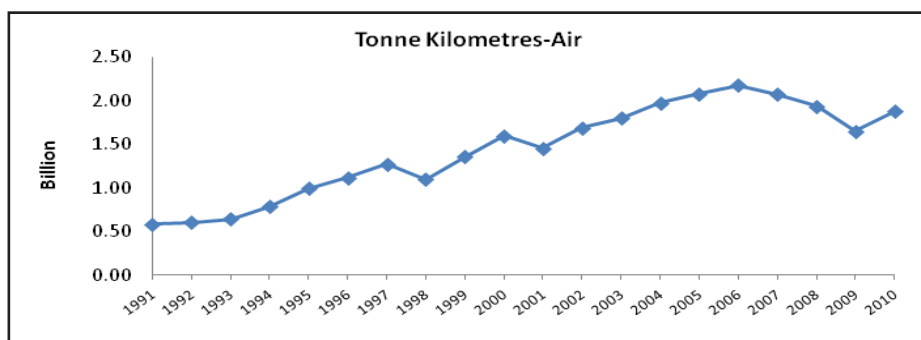


Figure 3.7.5: Freight movement by various modes⁷⁶

Source: TERI estimates adapted from MoT 2010, KTMB 2011

In the air transport, the tonne kilometres (including both domestic and international cargo) have increased at a compounded annual growth rate of 1.61% during the last ten years.

The freight carried in the maritime sector has increased from nearly 195 Mt in 2000 to more than 447 Mt in 2010 at a compounded annual growth rate of 8.68% in the last ten years. In terms of mode-wise energy consumption, as indicated in Figure 3.7.6, road transport accounted for the highest share of around 78.4%, followed by air (14.1%), and maritime (7%). The share of rail is marginal at 0.4%.⁷⁷

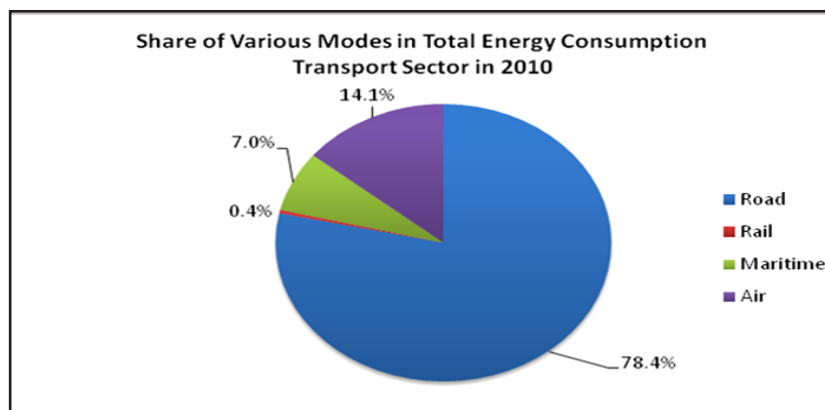


Figure 3.7.6: Share of various modes in total energy consumption in the transport sector

Source: TERI estimates adapted from NEB, 2010

⁷⁶ The total freight tonne kilometres for road transport include tonne kilometres by goods vehicles and other vehicles (others are assumed to be goods vehicles).

⁷⁷ The share of various modes in fuel consumption have been calculated (GHG Inventory Report, 2009) assuming the following: Road Transport: Petrol consumption in road = petrol consumption in transport sector; Diesel consumption in road transport = 74% of diesel consumption in transport sector; Natural gas consumption = natural gas consumption in transport sector. Railways: Diesel consumption in railways = 1% of diesel consumption in transport sector; Electricity consumption in railways = electricity consumption in transport sector. Maritime: Diesel consumption in maritime sector = 25% of diesel consumption in transport sector; Fuel Oil consumption in maritime sector = 100% of fuel oil consumption in transport sector. Air Transport: ATF consumption in air transport = ATF consumption in Transport sector

In terms of total fuel use in the transport sector (Figure 3.7.7), petrol accounted for the largest share of nearly 56%, followed by diesel (28%) and aviation turbine fuel (14%) with electricity, fuel oil and natural gas having a minor share in the total energy consumption in 2010. This clearly indicates the high dependence of the transport sector on petroleum fuels. The rapid growth in energy requirements by the sector, together with limited fuel switching possibilities are therefore a cause of concern both from the energy security as well as emissions point of view.

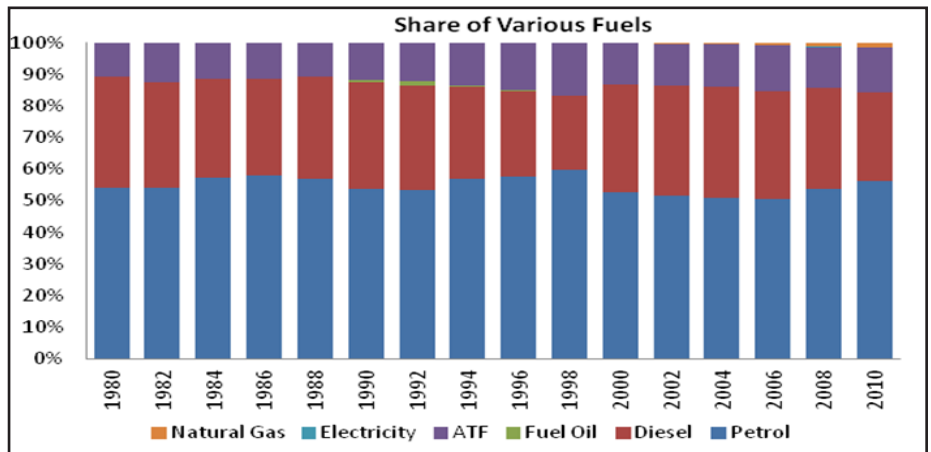


Figure 3.7.7: Share of various fuels in total energy consumption in the transport sector
Source: NC2, 2011

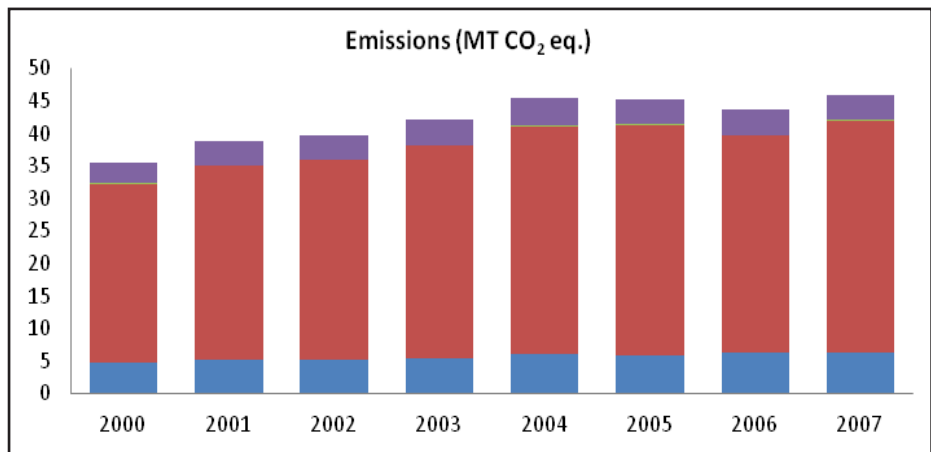


Figure 3.7.8: Emissions from the transport sector
Source: NC2, 2011

3.7.1.2 Key issues in the Transport Sector

The key issues identified in the transport sector are:

i. Growth in number of registered vehicles and personalised vehicles

The number of registered motor vehicles in Malaysia has been growing rapidly, registering an increase from 10.598 million in 2000 to 20.189 million in 2010. As indicated in Figure 3.7.9, the share of personalized vehicles i.e. motorcars and motorcycles in Malaysia is very high (92% in 2010) and has been increasing over the past few years. Accordingly, the share of bus, taxi and hire and drive car, goods and other vehicles has fallen from 10% in 2000 to 8% in 2010.

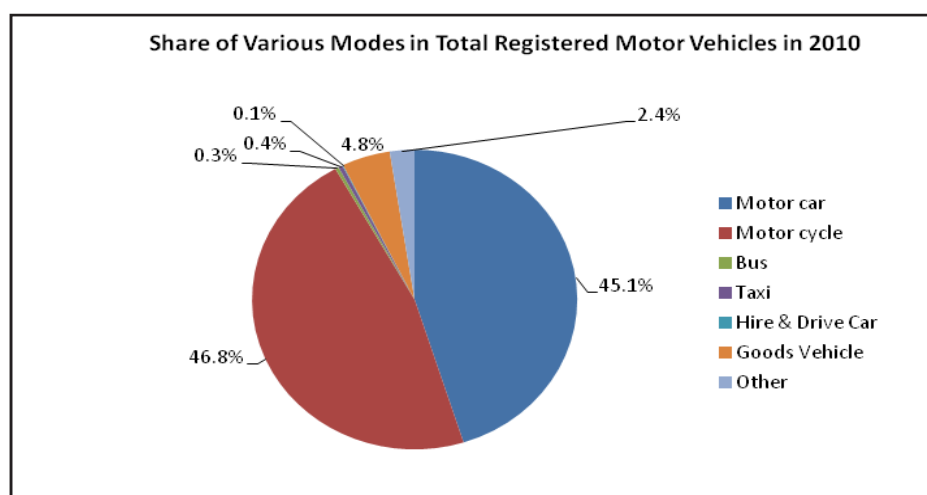


Figure 3.7.9: Share of various modes in total registered motor vehicles in 2010

Source: MoT, 2010

Some of the probable reasons for the rapid increase in number of registered vehicles and especially personalised vehicles include improvement in infrastructure in terms of increasing road length, increasing urbanization and per capita income, inadequacy of public transport infrastructure and services as well as the availability of highly subsidized fuels which leave little incentive for users to opt for public modes of transport. Furthermore, the National Automotive Policy adopted by the government have made national cars affordable and attractive to the public which has directly contributed to the increasing number of vehicles on the road.

ii. Low share of rail in passenger and freight movement

As indicated in Figure 3.7.10, the share of rail in both passenger and freight movement is very low. Since rail based movement is energy efficient, it is imperative to increase the share of rail in the total passenger kilometres and total freight tonne kilometres, to bring in benefits related not only to energy security and emission reduction but also reduced congestion and local air pollution.

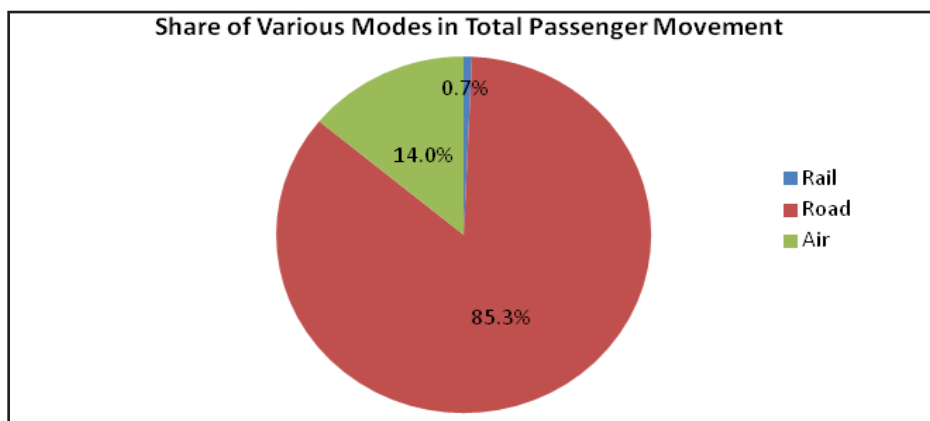


Figure 3.7.10: Share of various modes in total passenger and freight movement in 2010⁷⁸
Source: TERI estimates adapted from MoT 2010, KTMB 2011

iii. Heavy dependence on petroleum products

As indicated in Figure 3.7.11, the transport sector is highly dependent on petroleum products which account for more than 98% of the total fuel consumption in 2010. Petrol has the highest share, followed by diesel and aviation turbine fuel with electricity, fuel oil and natural gas having a minor share in the total.

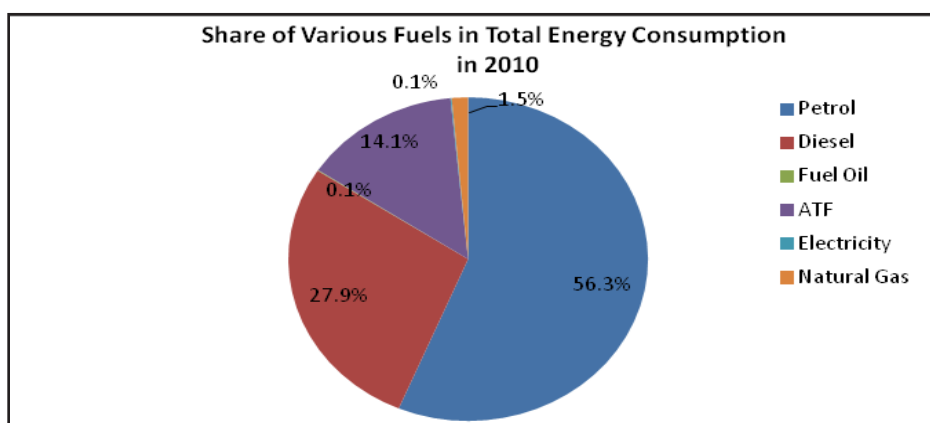


Figure 3.7.11: Share of various fuels in total energy consumption in transport sector
Source: NEB, 2010

iv. Highly subsidised price of petroleum fuels

Highly subsidized prices of petroleum fuels are another reason for the high usage of these fuels. This limits the incentive for people to shift to more efficient and cleaner options. In order to promote cleaner fuels, the fuel subsidy should be reviewed towards market pricing or tax levy.

⁷⁸ The passenger and freight movement by air includes both domestic and international, since the share of domestic passenger kilometres and tonne kilometres in the total passenger and tonne kilometres is not known.

3.7.2 Demand Projections and Technology Characterisation

3.7.2.1 Demand Projections

Based on the understanding of mode-wise movement in the past few years, the future demand of both passenger and freight movement in Malaysia was estimated.

Considering substitution between road and rail and other rail based modes, the passenger movement by road, rail and other rail based modes has been projected together. The passenger movement is assumed to be a function of gross domestic product and the population, while the passenger movement by air is assumed to be a function of GDP per capita.

Figure 3.7.12 shows the projected passenger movement by road and rail and also air transport.

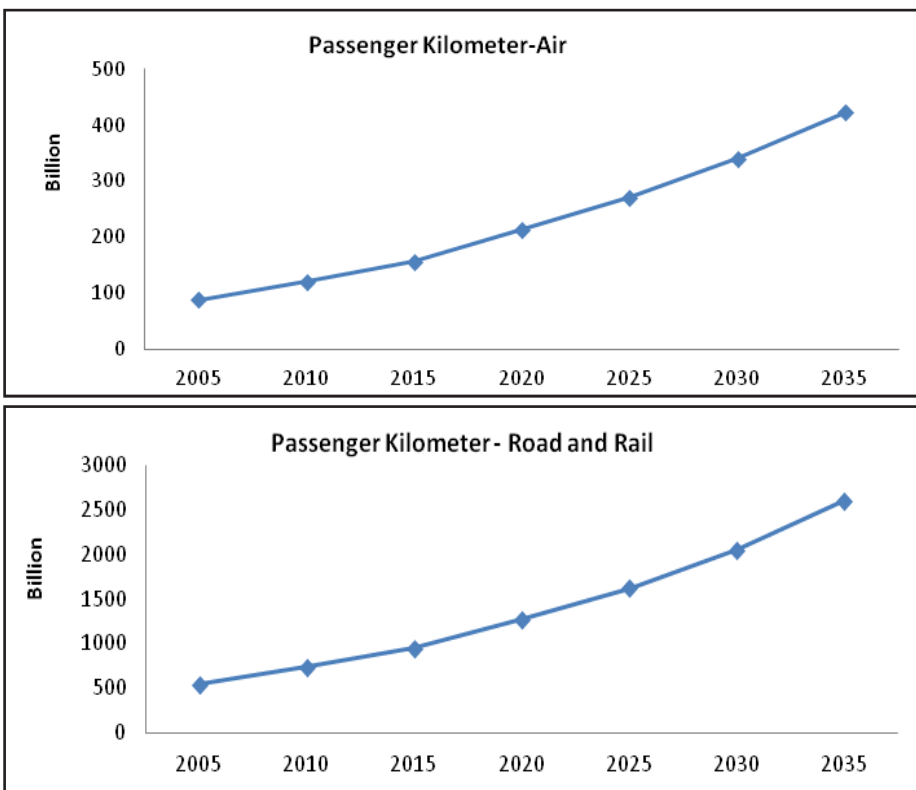


Figure 3.7.12: Projected passenger movement by various modes

Source: TERI analysis adapted from MoT 2010, KTMB 2011

The tonne kilometres have been projected assuming them to be a function of gross domestic product of agriculture and industry, since freight is expected to be dependant on the movement of agricultural and industry goods.

Figure 3.7.13 shows the projected tonne kilometres by road, rail and air. The tonne kilometres by road and rail have been projected together to allow for substitution between two modes. The projections for air are being done separately due to lack of information on share of domestic and international tonne kilometres in total tonne kilometres by air. The maritime freight movement is assumed to be a function of GDP of agriculture and industry

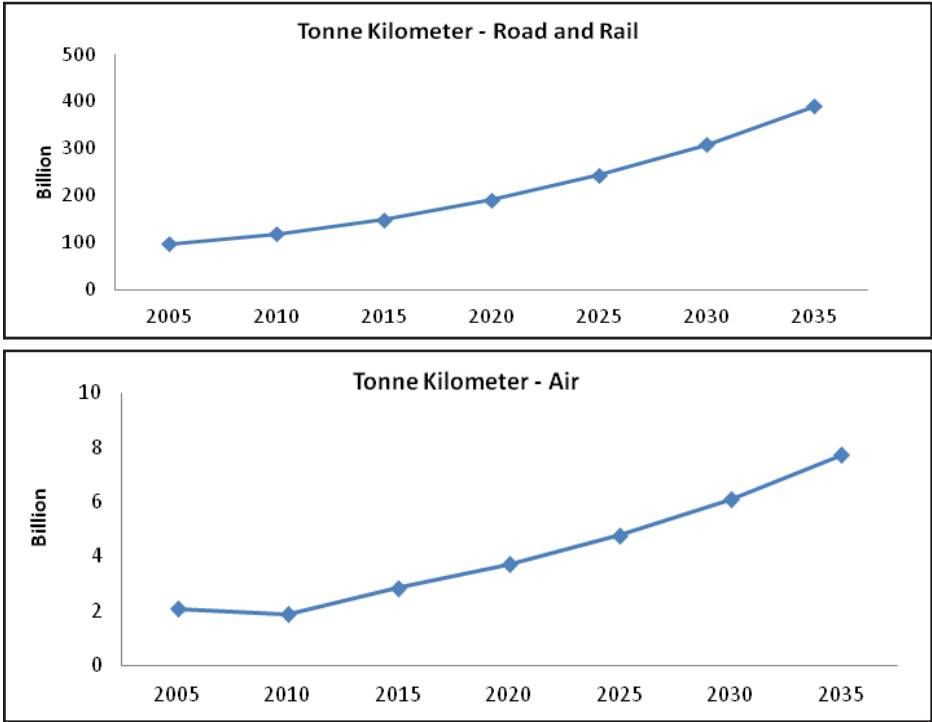


Figure 3.7.13: Projected tonne kilometres – Road, Rail and Air
Source: TERI analysis adapted from MoT 2010, KTMB 2011

Figure 3.7.14 shows the projected tonne carried by maritime sector.

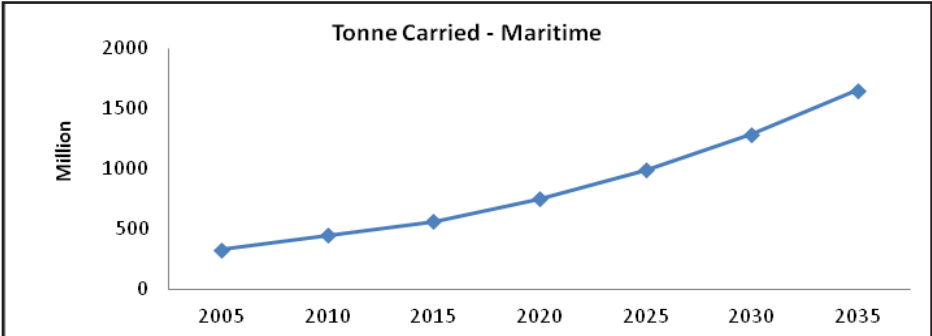


Figure 3.7.14: Projected tonne carried – Maritime Sector
Source: TERI analysis adapted from MoT 2010

3.7.2.2 Technology Characterisation

3.7.2.2.1 Road Transport

Given a certain level of passenger or freight movement demand in the future, the level of fuel use and the consequent emissions would depend not only on the mode but also on its efficiency. Accordingly, it is important to consider how the efficiencies of different modal choices in the transport sector compare with each other and to evaluate how the share of more efficient modes can be increased. This section provides the technology characterisation and the assumptions used in the analysis for transport sector in Malaysia.

Table 3.7.1: Technology in the road transport sector and the assumptions considered in the model⁷⁹

Technology	Start Year	Life (Years)	Efficiency (BPKM per ktoe/ BTKM per ktoe) in 2005	Investment Cost - (2005 RM Million per BPKM per annum)	Fixed Operating and Maintenance Cost- (2005 RM Million per BPKM per annum) (% of Investment Cost)
Car – Diesel	2005	15	0.0438	1225	2%
Car – Petrol	2005	15	0.0377	1188	2%
Car – Natural Gas	2005	15	0.0523	1243	2%
Car – Electric	2015	15	0.0930	2193	2%
Car – Petrol and Electric – Hybrid car	2015	15	0.0443	1462	2%
Motorcycle – Petrol	2005	15	0.1674	171	5%
Motorcycle – Electric	2015	15	0.2093	244	5%
Bus - CNG	2005	25	0.1064	136	2%
Bus – Diesel	2005	25	0.0912	131	2%
Taxi – Diesel	2005	15	0.0438	544	2%
Goods Vehicle	2005	20	0.0308	731	5%
Petrol Taxi	2005	15	0.0377	528	2%
Taxi NGV	2005	15	0.0523	552	2%

Source: TERI Analysis, 2012

⁷⁹ Table 3.7.1 mentions the assumptions taken for technology in the road transport sector. Using the efficiency data mentioned in this table and data on passenger kilometres (based on assumptions on occupancy and kilometers travelled in a year), the fuel consumption has been calculated.

The assumptions related to occupancy and distance travelled in a year is taken as given in Table 3.7.2.

Table 3.7.2: Assumptions related to occupancy and utilization - road transport

	Motor car	Motor cycle	Bus	Taxi	Hire & Drive Car	Goods Vehicle	Other
Utilization (Km/year)	26,664	15,000	60,000	60,000	26,664	40,000	40,000
Occupancy/ Load Factor	1.8	1.2	28	1.8	1.8	2	2

Source: PTM, 2005; UM report, 2005, TERI assumptions

Further, the bottom-up analysis approach adopted in the study necessitates a validation and understanding of fuel-wise technology distribution, in order to not only test the validity of the assumptions considered up to the current time period, but to also provide appropriate constraints to guide the future selection of technology options (e.g. to bring in cost barriers and consumer preferences). Due to lack of data, various assumptions had to be taken regarding the share of various modes fuel wise. Accordingly, the shares of passenger kilometres and freight tonne kilometres assumed for various modes of transport in 2004 and 2005 are provided in Table 3.7.3.

Table 3.7.3: Assumptions for calculating share of various modes of road transport in 2004 and 2005

Mode	Share (%)
Car	
Share of passenger kilometres by petrol car in total passenger kilometres by car	99
Share of passenger kilometre by diesel car in total passenger kilometres by cars	0.75
Share of passenger kilometre by natural gas car in total passenger kilometres by cars	0.25
Share of passenger kilometre by electric car in total passenger kilometres by cars	0
Share of passenger kilometre by hybrid car (electricity and petrol/ gasoline) in total passenger kilometres by cars	0
Motor Cycle	
Share of passenger kilometres by petrol/ gasoline motorcycle in total passenger kilometres by motorcycles	100
Share of passenger kilometres by electric motorcycle in total passenger kilometres by motorcycles	0
Bus	
Share of passenger kilometres by diesel bus in total passenger kilometres by bus	98
Share of passenger kilometres by natural gas bus in total passenger kilometres by bus	2

table continues...

Mode	Share (%)
Taxi and Hire and Drive Car	
Share of passenger kilometres by petrol taxi and hire and drive car in total passenger kilometre by taxi and hire and drive car	60
Share of passenger kilometres by diesel taxi and hire and drive car in total passenger kilometre by taxi and hire and drive car	20
Share of passenger kilometres by natural gas taxi and hire and drive car in total passenger kilometre by taxi and hire and drive car	20
Goods Vehicle	
Share of tonne kilometres by diesel vehicle in total (freight) tonne kilometres by road	100

Source: TERI Analysis, 2012

The fuel efficiency of all modes in the road transport has been assumed to increase by 1.25% every year in the Business-As-Usual scenario.

3.7.2.2.2 Rail Transport

In this section, the technologies and assumptions related to the rail sector that are considered are given.

Table 3.7.4: Technology in the rail transport sector for base year⁸⁰

Technology	Start Year	Life (Years)	BPKM/ BTKM	ktoe	Efficiency (BPKM/ktoe or BTKM/ktoe)	
					in 2005	in 2030
Diesel locomotive - Passenger	2005	25	1.181	20.304	0.0582	0.3124
Diesel Locomotive - Freight	2005	25	1.178	30.456	0.0387	0.1809
Electric Locomotive - Passenger	2005	25	4.09	5	0.6323	0.6323
Electric Locomotive - Freight	2015	25	-	-	0.4026	0.4026

Source: TERI Analysis adapted from KTMB, 2011

⁸⁰ Assumptions used for this: Efficiency for diesel locomotive passenger and freight: Calculated on the basis of assumption that 40% of total diesel consumption in railways is for passenger and 60% of total diesel consumption in railways is for freight movement.; Efficiency for electric locomotive passenger: Calculated assuming average distance travelled per passenger is 50% of the length of line.; Diesel consumption in railways=1% of diesel consumption in transport sector.;Electricity consumption in railways=electricity consumption in transport sector.

The efficiency in rail transport has been calculated using the following assumptions; only diesel is used for inter-city passenger and freight movement and the share of diesel consumption by passenger segment in total diesel consumption by rail is 40%, while share of diesel consumption by freight segment in total diesel consumption by rail is 60%. The electricity consumption has been calculated using the passenger ridership data for KTM Komuter, ETS, Putraline, Starline LRT, KL Monorail, KLIA Express, KLIA Transit and assuming average distance travelled per passenger to be 50% of the length of the rail. Freight movement in rail transport is assumed to be completely diesel based. The efficiency for electric locomotive in freight is calculated by assuming the ratio of BTKM per ktoe to BPKM per ktoe to be 0.6367 (average of BTKM per ktoe to BPKM per ktoe for diesel from 2005 to 2010). The efficiency has been calculated similarly for 2010⁸¹ and the same growth rate between 2005 and 2010 is assumed to continue in the future in the Business-As-Usual Scenario for diesel locomotive of passenger and freight. For passenger electric locomotive, average from 2005 to 2010 has been taken and it is assumed to be constant in the future. For the freight electric locomotive, the ratio 0.6367 is used in future for Business-As-Usual scenario. i.e. the ratio of BTKM per ktoe to BPKM per ktoe for electric traction is assumed to be 0.6367. The following Table 3.7.5 provides assumptions regarding cost, capacity and average utilization.

Table 3.7.5: Assumptions related to cost, capacity and average distance travelled

	No. of coaches / wagons per train	Capacity (No of passenger per coach-passenger/tonne carried per wagon-freight)	Average Km Travelled per year	Average occupancy/ Load factor	Investment Cost - (2005 RM Million per BPKM per annum/2005 RM Million per BTKM per annum)	Fixed Operating and Maintenance Cost- (2005 RM Million per BPKM per annum/ 2005 RM Million per BTKM per annum) (% of Investment Cost)
Diesel-Passenger	9	45	129,000	95%	610	5%
Electric - Passenger	9	45	129,000	95%	663	5%
Diesel - Freight	30	40	111,000	95%	146	5%
Electric-Freight	30	40	111,000	95%	166	5%

Source: TERI analysis adapted from MoT 2010, KTMB 2011

⁸¹ Total Diesel/ Electricity Consumption in rail transport for 2010 is 46.94 ktoe/18 ktoe respectively

3.7.2.2.3 Air Transport

In this section, the technologies considered and the assumptions related to the air sector that are considered are given.

Table 3.7.6: Technology in the air transport sector for base year⁸²

Technology	Start Year	Life (Years)	BPKM/ BTKM	ktoe	Efficiency (BPKM/ktoe or BTKM/ktoe)	
					in 2005	in 2030
Aircraft - Passenger	2005	25	88.42	1486	0.0595	0.0759
Aircraft - Freight	2005	30	2.08	524	0.0040	0.0051

Source: TERI analysis adapted from MAS, 2012

The efficiency has been calculated similarly for 2010⁸³ and rate of growth between 2005 and 2010 is assumed to be same in the future in the Business-As-Usual Scenario. The assumptions taken regarding cost of passenger movement by air transport are given in Table 3.7.7.

Table 3.7.7: Assumptions taken to calculate costs for air transport

Aircraft	Carrying Capacity (No of passenger (passenger) /kg carried (freight))	Distance Travelled per year (Km)	Average occupancy/ Load factor	Investment Cost - (2005 RM Million per BPKM per annum/ 2005 RM Million per BTKM per annum)	Fixed Operating and Maintenance Cost- (2005 RM Million per BPKM per annum/ 2005 RM Million per BTKM per annum) (% of Investment Cost)
Passenger					
B 737-800	162	1,000,000	75%	1,949	5%
B 777 - 200	282	1,000,000	75%	3,691	5%
A 380-800	494	1,000,000	75%	2,841	5%
Average				2,827	5%
Freight					
Boeing 747-400 F	120, 000	1,000,000	75%	8,772	5%
A 330-200 F	68,000	1,000,000	75%	12,040	5%
Average				10,406	5%

Source: TERI analysis adapted from MAS, 2012

⁸² To calculate the energy consumption by passenger segment and freight segment in air transport, it is assumed that energy consumption per BTKM is nearly 15 times the energy consumption per BPKM. This is then used to calculate the efficiency i.e. BPKM per ktoe and BTKM per ktoe.

⁸³ This has been estimated based on source of Review of Maritime Transport, 2011, United Nations Conference on Trade and Development, United Nations, New York and Geneva, 2011.

3.7.2.2.4 Maritime

Table 3.7.8: Technology in the maritime sector for base year

Technology	Start Year	Life (Years)	Million Tonne	ktoe	Efficiency (Million Tonne per ktoe)	
					in 2005	in 2030
Maritime – Freight	2005	25	329.752	1,273	0.2590	1.7018

Source: TERI Analysis, 2012

Table 3.7.9: Cost Assumptions for the maritime sector

Cost	Million Malaysian Ringgit per million tonne carried per annum
Investment Cost	359 ⁸⁴
Fixed Operating and Maintenance Cost (% of Investment Cost)	5%

Source: TERI Analysis, 2012

Tables 3.7.8 and 3.7.9 provide the technology and cost assumptions for the maritime sector, while Table 3.7.10 shows the assumptions for share of fuels used in the maritime sector.

Table 3.7.10: Share of diesel and fuel oil in total energy consumption for maritime sector (per tonne carried)

Share of Diesel in total energy consumption	99.4%
Share of Fuel Oil in total energy consumption	0.6%

Source: TERI Analysis, 2012

The average intensity for year 2005 has been calculated by dividing the total fuel consumption by the total tonnes carried. The efficiency has been calculated similarly for year 2010⁸⁵ and rate of growth between 2005 and 2010 is assumed to be the same in the future in the Business-As-Usual Scenario. Accordingly, the efficiency improves to 1.7018 million tonne per ktoe in 2030.

⁸⁴ This has been estimated based on source of Review of Maritime Transport, 2011, United Nations Conference on Trade and Development, United Nations, New York and Geneva, 2011.

⁸⁵ Total Diesel Consumption in maritime sector in 2010: 1174 ktoe.
Total Fuel Oil Consumption in maritime sector in 2010: 12 ktoe.

3.7.3 Scenarios

In the transport sector, the Business-As-Usual scenario (BAU) and various alternative scenarios have been developed with the view to examine the scope for energy and emissions savings in the sector by undertaking various measures. The following section describes the set-up of these scenarios.

3.7.3.1 Business-As-Usual Scenario

In the Business-As-Usual Scenario (BAU), certain assumptions are considered as described in Table 3.7.11.

Table 3.7.11: Description of assumptions in business-as-usual scenario

Assumptions	Descriptions
(a) Share of passenger kilometre by rail in total surface passenger kilometre	The share of passenger kilometres by rail (including other rail based modes) is assumed to decrease from around 1% in total surface passenger movement (passenger kilometre) in 2005 and around 0.76% in 2035.
(b) Share of freight tonne kilometre by rail in total surface freight tonne kilometre	The share of tonne kilometres by rail in total surface freight movement (tonne kilometre) is assumed to decline from around 1% in 2005 to around 0.1% in 2035
(c) Share of freight tonne kilometre by rail in total surface freight tonne kilometre	The share of tonne kilometres by rail in total surface freight movement (tonne kilometre) is assumed to decline from around 1% in 2005 to around 0.1% in 2035
(d) Share of freight tonne kilometre by electric in total freight tonne kilometre by rail	The share of tonne kilometre - electric in total tonne kilometre by rail is assumed to be 0%.
(e) Share of passenger kilometre by public transport in total passenger kilometre by road	The share of passenger kilometre by public transport is assumed to be 19.26% in 2005, 17.20% in 2010 and declining to 15.80% in 2035 in total passenger kilometre by road
(f) Share of passenger kilometre by bus in total passenger kilometre by public transport	The share of passenger kilometre by bus in total passenger kilometre by public transport is assumed to be around 92%.
(g) Share of passenger kilometre by car in total passenger kilometre by private transport	The share of passenger kilometre by car in total passenger kilometre by private transport is assumed to be 71.12% in 2005, 72.02% in 2010 and around 73.43% in 2035.
(h) Share of passenger kilometre by electric car in total passenger kilometre by cars	The share of passenger kilometre by electric car is assumed to be 0% in total passenger kilometres by cars.

table continues...

Assumptions	Descriptions
(i) Share of passenger kilometre by electric hybrid car in total passenger kilometre by cars	The share of passenger kilometre by electric hybrid car is assumed to be 0% in total passenger kilometres by cars.
(j) Share of passenger kilometre by gasoline cars in total passenger kilometre by cars	The share of passenger kilometre by gasoline / petrol car in total passenger kilometre by car is assumed to be around 99% in 2005, 98% in 2010 and declining to 93% in 2035.
(k) Share of passenger kilometre by CNG car in total passenger kilometre by cars	The share of passenger kilometre by CNG car in total passenger kilometre by car is assumed to be around 0.25% in 2005, 1% in 2010 and increasing to 6% in 2035.
(l) Share of passenger kilometre by gasoline taxis in total passenger kilometre by taxis	The share of passenger kilometre by gasoline / petrol taxi in total passenger kilometres by taxi is assumed to be around 60% in 2005, 58% in 2010 and declining to 48% in 2035.
(m) Share of passenger kilometre by CNG taxis in total passenger kilometre by taxis	The share of passenger kilometre by CNG taxi in total passenger kilometre by taxi is assumed to be around 20% in 2005, 22% in 2010 and increasing to 45% in 2035.
(n) Share of passenger kilometre by electric motorcycles in total passenger kilometre by motorcycles	The share of passenger kilometres by electric motorcycle is assumed to be 0% in total passenger kilometre by motorcycle. All motorcycles are assumed to be using petrol/ gasoline as fuel.
(o) Share of passenger kilometre by CNG buses in total passenger kilometre by buses	The share of passenger kilometre by CNG buses in total passenger kilometres by buses is assumed to be 2% in 2005, 5% in 2010 and increasing to 15% in 2035. The rest of passenger kilometres are assumed to be by diesel buses.
(p) Freight/ Goods – Road Transport	The entire freight / goods vehicle – road transport are assumed to be using diesel as fuel.
(q) Penetration rate of Bio-diesel i.e. share of Bio-diesel in total diesel	The penetration rate of Bio-diesel with 5% bio-fuel content i.e. share of Bio-diesel in total diesel is assumed to 0% in 2005, 2% in 2010, 5% in 2015, 10% in 2020, 20% by 2030 and 25% in 2035. This means that the share of bio-fuel in diesel is assumed to be around 0.1% in 2010, 0.25% in 2015, 0.5% in 2020, 1% in 2030 and 1.25% in 2035.

3.7.3.2 Alternative Scenarios

Table 3.7.12 lists the scenarios examined in the transport sector and provides a description of each of these scenarios.

Table 3.7.12: Scenarios for transport sector

Scenario	Descriptions
TPT_RAIL	- In this scenario, share of passenger kilometre by rail (including other rail based modes) is increased in total surface passenger and total surface freight tonne kilometre vis-à-vis road. - Rail passenger kilometre share is assumed to increase to 10% of total surface passenger kilometre by 2020 and 20% by 2030 and 25% by 2035. - Rail freight tonne kilometre share is assumed to increase to 10% of total surface freight tonne kilometre by 2020 and 20% by 2030 and 25% by 2035.
TPT_PUB	- In this scenario, the share of passenger kilometre by public transport is assumed to increase in total passenger kilometre by road. - Share of passenger kilometre by Public Transport modes is assumed to increase to 40% by 2020 and 50% by 2030 and 55% by 2035 of total passenger kilometre by road.
TPT_EFF	- In this scenario, the fuel efficiency is assumed to improve every year in road transport. - In this scenario, the fuel efficiency in road transport is assumed to improve every year by 1.5%.
TPT_ALTFUEL	- In this scenario, the use of alternative and cleaner fuels is increased. - CNG - Share of passenger kilometres by CNG cars is assumed to be 5% by 2020, 8% by 2030 and 10% by 2035 of total passenger kilometres by car. - Share of passenger kilometre by CNG Buses is assumed to be 15% by 2020, 30% by 2030 and 40% by 2035 of total passenger kilometre by buses. - Share of passenger kilometre by CNG Taxis to be 40% by 2020, 50% by 2030 and 55% by 2035 of total passenger kilometres by taxis.

table continues...

Scenario	Descriptions
	Electrification of Railways - Share of Freight Movement – tonne kilometres - by electric in total (freight)tonne kilometres by rail is assumed to be 20% by 2020, 40% by 2030 and 50% by 2035 - Share of passenger kilometres by electric in total passenger kilometres by rail is assumed to be around 74% by 2015, 78% by 2020, around 83.12% by 2030 and 85.82% by 2035. Electric Cars - Share of passenger kilometres by electric cars is assumed to be 10% by 2020, 20% by 2030 and 25% by 2035 in total passenger kilometres by car. Electric Hybrid Car - Share of passenger kilometres by electric hybrid cars is assumed to be 10% by 2020, 20% by 2030 and 25% by 2035 in total passenger kilometres by car. Electric Motorcycles - Share of passenger kilometres by electric motorcycles is assumed to be 10% by 2020, 20% by 2030 and 25% by 2035 in total passenger kilometres by motorcycles. Bio-diesel - The share of biodiesel with 5% bio fuel content in total diesel is assumed to be around 20% in 2015, 35% by 2020, 50% by 2030 and 60% by 2035. This means that the share of bio fuel in diesel to be around 1% in 2015, 1.75% by 2020, 2.5% by 2030 and 3% by 2035.⁸⁶ Bio-ethanol - The share of bioethanol with 5% bio fuel content in total gasoline/petrol is assumed to be nearly 0% in 2015, 10% by 2030 and 12.5% by 2035. This means that the share of bio fuel in petrol to be nearly 0% in 2015, 0.5% by 2030 and 0.63% by 2035.⁸⁷
TPT_HYB	A hybrid scenario incorporating all the above scenarios

⁸⁶ The price of bio-diesel is assumed to be the same as diesel

⁸⁷ The price of bio-ethanol is assumed to be the same as petrol

3.8 Industrial Sector and Industrial Processes

3.8.1 Introduction

Malaysia is a developing country whose economic growth has been largely fuelled by its growing Industrial sector. The Industrial sector accounted for a significant 37% share of the Malaysian gross domestic product in 2010. The GDP of the Industrial sector in Malaysia has grown at a CAGR of 5% during 1990 to 2010⁸⁸. With services sector becoming more important and playing a more prominent role towards value add of the Malaysian economy, growth rate of the industrial sector is expected to decline slightly. The sector's GDP is estimated to grow from RM 212 billion in 2010 to RM 509 billion by 2030 at a CAGR of 4.5%.

Industrial sector comprises of manufacturing, construction and mining and quarrying.

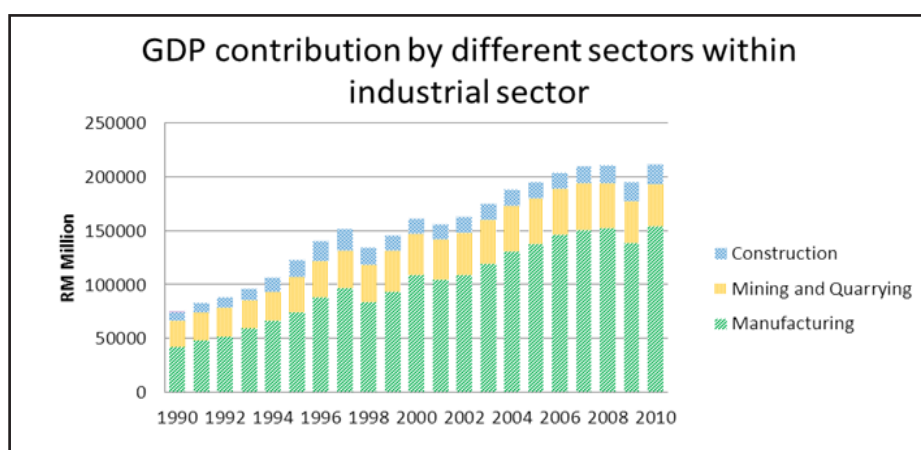


Figure 3.8.1: GDP of the industrial sector

Source: Department of Statistics, 2010

As reported in Figure 3.8.1, within the industrial sector, the manufacturing emerges as the biggest contributor to the GDP of the industrial sector⁸⁹. The share of manufacturing in the total GDP of the industrial sector increased from 57% in 1990 to 71% in 2010. The manufacturing is also the second largest employer in Malaysia with 1.69 million workers employed in this category in 2009. The largest employer was 'Wholesale and Retail Trade, Repair of Motor Vehicles, Motorcycles and Personal and Household Goods' with 1.83 million employees, and the agriculture sector was the third largest employing 1.34 million workers (Department of Statistics, Malaysia 2010).

⁸⁸ www.statistics.gov.my

⁸⁹ GDP is at constant prices with base year as 2000

While healthy growth in the industrial sector results in a healthy increase of gross domestic product (GDP), it also affects the ability to maintain fuel supply or reserves. There is a growing concern over energy consumption and its adverse impact on the environment. It is important to analyse the energy consumption in the industrial sector as it has emerged as one of the largest energy consuming sectors in the recent years. Till the year 2008, Industrial sector was the largest consumer of energy in Malaysia accounting for 42% of the total energy consumption (NEB, 2010). However, since 2009, transport sector has emerged as the biggest energy consumer in Malaysia replacing industrial sector. Table 3.8.1 shows the break-up of the energy consumption in the Industrial sector of Malaysia from 1990 till 2010.

Table 3.8.1: Total energy consumed for industrial sector in '000 toe (% shares)

Year	Natural Gas	Total Petroleum Products	Coal and Coke	Electricity	Total energy consumed
1990	476(9%)	3,481(65%)	513(10%)	830(16%)	5,300(100%)
2000	2,327(20%)	5,283(46%)	991(9%)	2,805(25%)	11,406(100%)
2007	8,078(42%)	6,089(32%)	1,361(7%)	3,587(19%)	19,116(100%)
2008	8,474(44%)	5,264(28%)	1,713(9%)	3,687(19%)	19,138(100%)
2009	4,544(32%)	4,436(31%)	1,613(11%)	3,719 (26%)	14,312(100%)
2010	3,864(31%)	2,798(22%)	1,826(15%)	3,994(32%)	12,482(100%)

Source: NEB 2010

Diesel and fuel oil are the major petroleum products consumed in the industrial sector in Malaysia. Figure 3.8.2 shows the consumption of various petroleum products in the Industrial sector over the last 10 years.

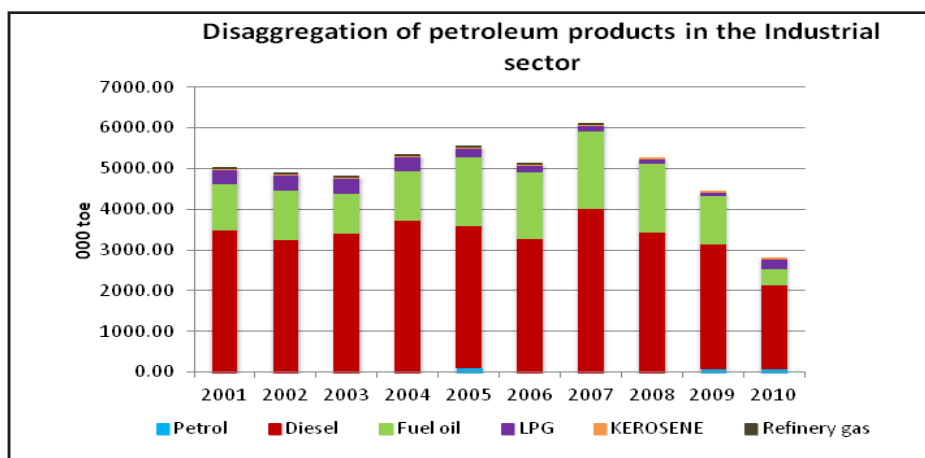


Figure 3.8.2: Disaggregation of petroleum products in the industrial sector
Source: NEB 2010

The final energy consumption in the Industrial sector has increased from 5.30 Mtoe in 1990 to 11.41 Mtoe in 2000 and to 19.14 Mtoe in 2008. However, in 2009 and 2010, there has been a continuous decline in the energy consumption in the industrial sector (Table 3.8.1), and also the contribution of the industrial sector to the total GDP of the Malaysian economy declined from 40% in 2007 to 37% in 2010⁹⁰.

Energy intensity of the industrial sector increased from 103.72 toe/RM Million in 2000 to 126.90 toe/RM Million in 2007, and subsequently declined to 81.70 toe/RM Million in 2010 as indicated in Figure 3.8.3.

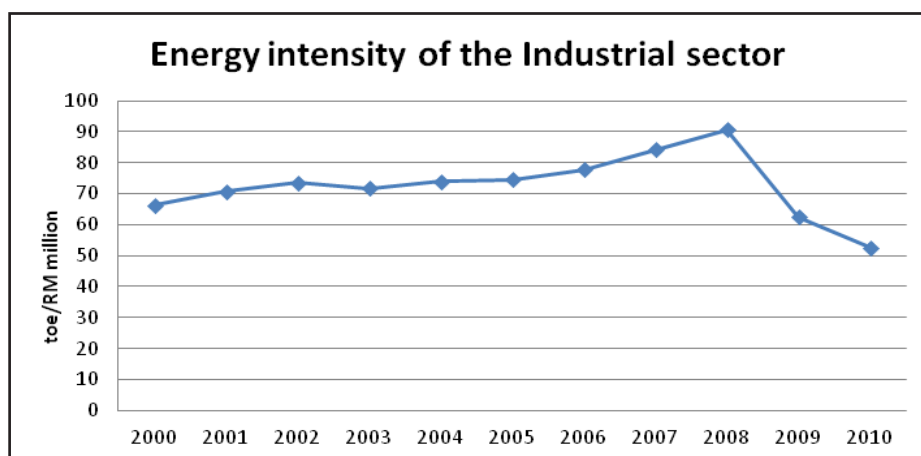


Figure 3.8.3: Energy intensity of industrial sector
Source: NEB 2010

⁹⁰ Department of Statistics, Malaysia, 2010

3.8.1.1 Industrial Processes

In addition to emissions from fossil fuel combustion, CO₂ emissions also result due to the various processes that are involved in the manufacturing of industrial goods. Industrial processes emissions occur when materials are transformed from one substance to another in an industrial setting. Emissions are a result of the chemical reactions involved in these processes. Greenhouse gas emissions are produced as the by-products of various non-energy-related industrial activities. That is, these emissions are produced from an industrial processes itself and are not directly a result of energy consumed during the process. Industrial processes emitted 14.1 MtCO₂ eq. in 2000 (NC2, 2011). The various industrial processes that contribute to emissions are mineral products, cement production, lime production, limestone & dolomite use, chemical industry, ammonia production, nitric acid production, carbide production, petrochemicals, metal production and iron & steel production.

3.8.2 Industrial Projections

The production of industrial goods in two energy-intensive industrial sectors i.e. steel and cement is estimated and projected till 2030. Due to the paucity of data for other energy intensive industries such as glass, ceramic, wood products, rubber products, pulp and paper and food products (including beverages and tobacco), all these industries are clubbed together as other industries and final energy is projected till 2030.

3.8.2.1 Steel Production

Steel is crucial to the development of any modern economy and infrastructure. The iron & steel industry provides an important linkage for the supply of basic raw materials and components to other sectors of the Malaysian economy, especially the construction industry, automotive industry, machinery industry and engineering fabrication industry.

Figure 3.8.4 shows the production of steel in Malaysia from 1991 till 2010. The production of iron and steel constantly grew since 1991 till 2007 except in 1998 and 2004. Steel production declined in 1998 due to the East Asian crisis of 1997-98. The impact of economic slowdown and recession in 2008 were also witnessed in the metals industry and the output of steel fell from 5.89 million tonnes in 2007 to 4.97 million tonnes in 2010.

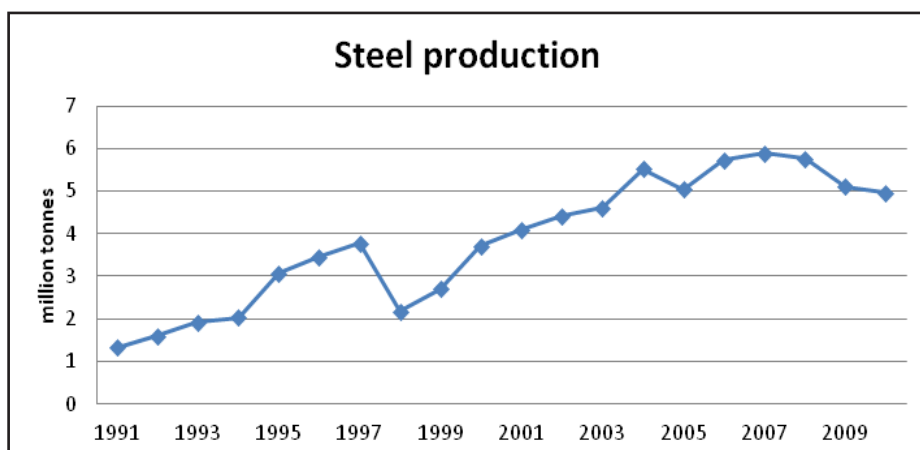


Figure 3.8.4: Steel production in Malaysia

Source: DOS, 2010

The Third Industrial Master Plan 2006-2020 (IMP3) stresses upon enhancing the competitiveness of the iron & steel industry to support the growth of the manufacturing and construction sectors and attracting new investments in niche areas in the iron & steel industry.

Regression analysis was used to project the future steel production in the country. Production of steel has been correlated with the GDP contributed by the industrial sector to estimate the steel production. Figure 3.8.5 shows the steel production for Malaysia projected till 2030.

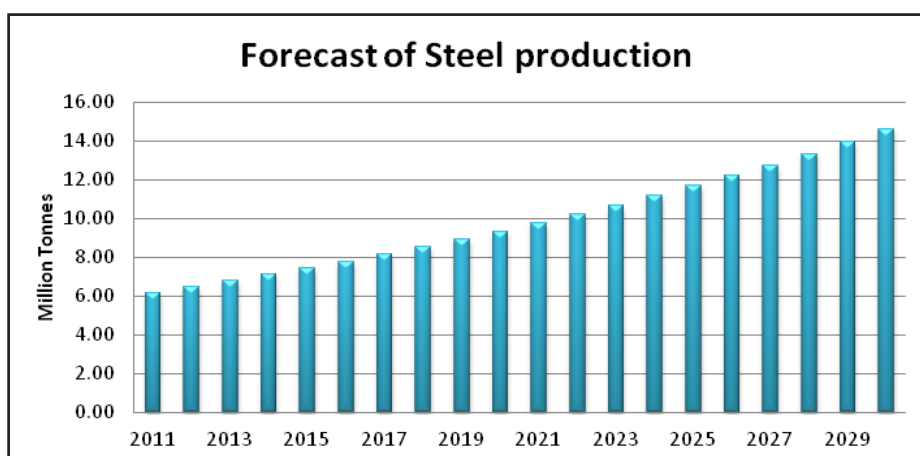


Figure 3.8.5: Forecast of steel production in Malaysia

Source: TERI Estimates, 2012

3.8.2.2 Cement Production

Cement is a key component of infrastructure development. It is used in the construction of buildings, bridges, roads, airports, and so on. Therefore cement industry is a highly capital intensive and vital industry for a country.

Production of cement in Malaysia increased from 16.66 million tonnes in 2005 to 19.76 million tonnes in 2010 (Compendium of Environmental Statistics, Malaysia). The CAGR (Compound annual growth rate) of cement production from 2005 till 2010 was 3.00%. The same growth rate has been applied to the current production to estimate future cement production. Figure 3.8.6 shows the cement production projected till 2030 for Malaysia.

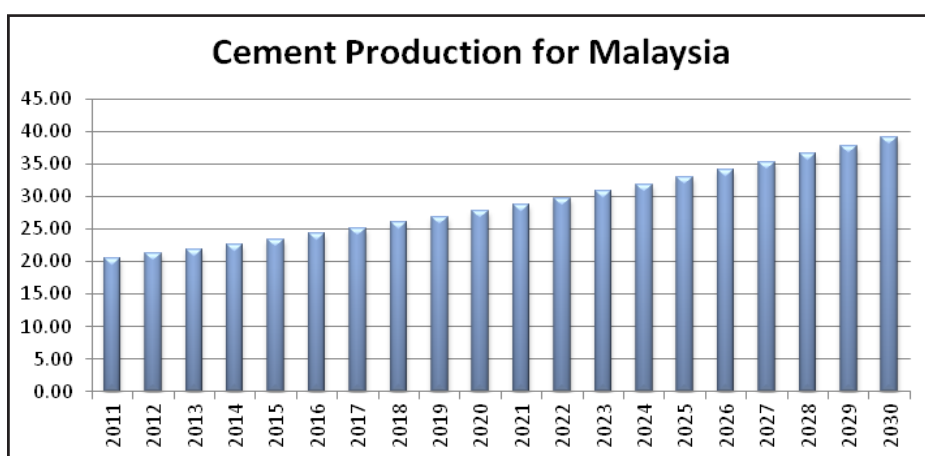


Figure 3.8.6: Forecast of cement production in Malaysia
Source: TERI Estimates, 2012

3.8.3 Technological Characterisation of Options

This section gives a description of the status of each of the technological options and specific energy consumption under steel and cement sectors.

3.8.3.1 Iron & Steel

The iron and steel industry is acknowledged as one of the most energy intensive industrial subsectors. Three routes are usually employed to make steel. In the primary route, iron ore is reduced to iron in blast furnaces using mostly coke or coal then processed into steel. In the second route scrap steel is melted in electric-arc furnaces to produce crude steel that is further processed. The remaining steel production uses natural gas to produce direct reduced iron (DRI). DRI cannot be used in primary steel plants, and is mainly used as an alternative iron input in electric arc furnaces.

Steel mills in Malaysia manufacture steel using Electric Arc Furnace (EAF) technology where steel scrap is the main input. Secondary steel is produced in an electric arc furnace (EAF) using scrap. In this process, the coke production, pig iron production, and steel production steps are omitted, resulting in much lower energy consumption. The scrap/EAF route is much less energy-intensive (using 4 GJ to 6 GJ per tonne of iron produced when using 100% scrap) than the BF/BOF route (which uses 13 GJ to 14 GJ per tonne of iron produced)⁹¹. Table 3.8.2 shows the specific energy consumption for the steel plants in Malaysia.

Table 3.8.2: Specific energy consumption (SEC) for the steel sector of Malaysia

Year	Steel production (Mt)	Coal consumption in steel (ktoe)	Natural gas consumption in steel (ktoe)	Electricity consumption (kwh) ⁹²	Specific energy consumption (GJ/tonne)
2004	5.52	58	109.56	3350.03	3.46
2005	5.03	46	179.71	3055.94	4.06
2006	5.73	52	263.68	3475.07	4.49
2007	5.89	78	343.05	3572.19	5.18
2008	5.76	72	358.92	3497.23	5.32
2009	5.10	60	322.92	3097.24	5.33
2010	4.97	61	360.78	3014.91	5.74

Source: Adapted from DOS, 2010

The specific energy consumption (total energy consumed/tonne of steel production) has been increasing since 2004 and reached 5.74 GJ/t in 2010. The SEC for the steel plants, although increasing in the past few years fares well when compared to the world best standards.

Assumptions for the BAU Scenario:

- The specific gas consumption was 3.04 GJ/t in 2010.
- The specific coal consumption was 0.51 GJ/t in 2010.
- The specific coal consumption and specific natural gas consumption defined in GJ/t has been kept at 2010 levels till 2030.
- The specific electrical energy consumption for steel production is 607 kwh/t. (MIEEIP Audit report, 2001).
- The specific electrical energy consumption has been kept constant at 607 kwh/t till 2030.
- The specific thermal energy consumption and electrical energy consumption has been added to calculate total energy consumption per million tonne of steel production.

⁹¹ IEA Energy Technology Roadmap 2010

⁹² Data on electricity consumption in steel sector was not provided. The audit report of steel sector 2001 reported the specific electricity consumption as 607 kwh/t. It is assumed that the specific electricity consumption has remained at this level till 2010. This SEC of 607 kwh/t has been multiplied with the production of steel to estimate the past electricity consumption in the steel sector.

3.8.3.2 Cement

Cement production is also highly energy-intensive. The major energy uses are fuel for the production of clinker and electricity for grinding raw materials and finished cement. Coal dominates in clinker making. The specific thermal energy consumption in cement sector for world's best plants is 650 kcal/kg of clinker⁹³ (1.9 GJ/t of cement assuming a 70% clinker to cement ratio). The specific thermal energy consumption for cement production for Malaysia is shown in Table 3.8.3. As production process becomes more energy efficient over the years, specific energy consumption should decline. In contrast, the specific thermal energy consumption for cement production has increased from 2.47 GJ/t (725 kcal/kg of clinker) in 2007 to 3.76 GJ/t in 2010 (984 kcal/kg of clinker)⁹⁴. The performance of the cement sector in terms of energy efficiency has deteriorated in the last three years while no clear reasons were apparent for the same.

Table 3.8.3: Specific thermal energy consumption for the cement sector in Malaysia

Year	Clinker installed capacity (Mt)	Cement installed capacity (Mt)	Cement demand (Mt)	Cement Production (Mt)	Coal & natural gas consumption (Mtoe)	Specific energy consumption (GJ/t of cement) (kcal/kg of clinker) ⁹⁵	
2006	17.80	28.30	15.74	19.45	1.29	2.78	726.24
2007	17.80	28.30	15.86	21.90	1.29	2.47	725.22
2008	17.80	28.30	16.96	19.62	1.65	3.53	928.79
2009	18.25	28.48	16.05	19.45	1.56	3.36	857.07
2010	18.08	28.89	16.62	19.76	1.78	3.76	984.08

Source: Adapted from DOS, 2010

Assumptions for BAU scenario:

- The specific thermal energy consumption for cement production for Malaysia for 2010 was 3.76 GJ/t.
- It has been assumed that the specific fuel consumption for the cement plants of Malaysia would remain at this particular level of 3.76 GJ/t till 2030.
- The specific electrical energy consumption for the dry cement plants of India stands at 79 kWh/t (TEDDY 2011/12).
- It has been assumed that the specific electrical consumption for the BAU is 10% higher than that of Indian standards and would remain at that level i.e 87 kWh/t till 2030.
- The specific thermal energy consumption and electrical energy consumption has been added to calculate total energy consumption per million tonne of cement production.

⁹³ Annual Report of Cement Manufacturers Association, 2010

⁹⁴ Energy Commission, Malaysia

⁹⁵ Data on clinker production was not known. It is assumed that production of clinker is same as the installed capacity of clinker.

3.8.3.3 Other Industries

Other industries considered here are the glass industries, ceramic industries, wood products, rubber products, pulp and paper and food products (including beverages and tobacco). In order to estimate the energy consumption in other industries, energy consumption for steel and cement sector estimated for BAU has been subtracted from total energy consumption estimated for the industrial sector. The residual obtained is the energy consumption for these other industries.

Assumptions used for BAU:

- i. Energy consumption has been estimated for the whole industrial sector ⁹⁶.
- i. Proportionate share of fuels (coal, natural gas, petroleum products and electricity) in 2010 has been multiplied with final energy consumption to estimate the consumption of coal, natural gas, petroleum products and electricity separately.
- iii. Energy consumption for steel and cement sector estimated for BAU has been subtracted from total energy consumption estimated for the industrial sector to estimate the energy consumption from other industries.

Figure 3.8.7 shows the final energy consumption projected for other industries till 2030.

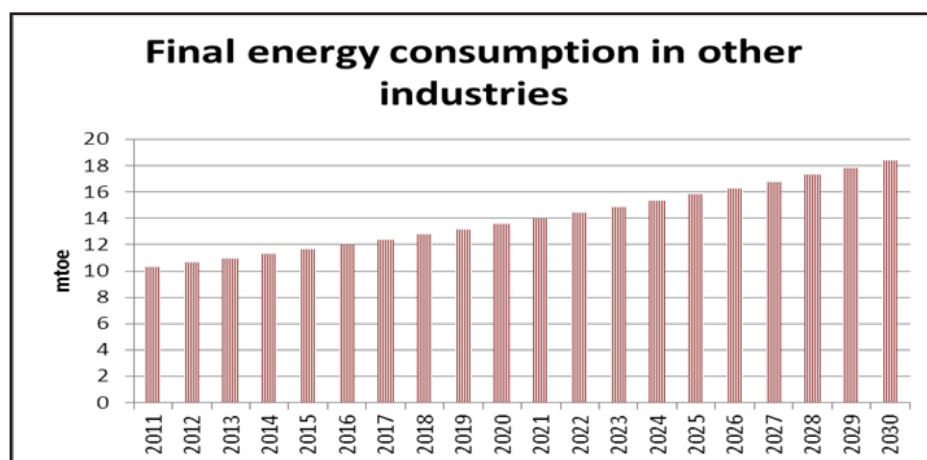


Figure 3.8.7: Forecast of energy consumption in other industries Malaysia

Source: TERI Estimates, 2012

⁹⁶ The CAGR of energy intensity of the industrial sector decline by 2% during 1990 to 2010. It is assumed that energy intensity would decline at 1% from 2010 till 2030. Energy intensity has been multiplied with GDP of the manufacturing sector to get the total energy consumption of the industrial sector.

Table 3.8.4 shows the technology and cost assumptions considered in the analysis for the industrial sector.

Table 3.8.4: Technology and cost assumptions for industrial sector

Technology	Life	Start Year	Efficiency (Million tonnes per ktoe)	Investment Cost (2005 Million RM per million tonne per annum)	Fixed Operation and Maintenance Cost (% of Investment Cost)
Cement – Dry Process	20	2005	0.0136 (Year 2005) 0.0103 (Year 2010)	322.0721	2.5%
Iron and Steel –Scrap– EAF	30	2005	0.0103 (Year 2005) 0.0073 (Year 2010)	734.9773	4%
Technology for Other Industries	35	2005	1	0	0

Source: TERI Estimates, 2012⁹⁷

The efficiency in the years 2015-2035 is assumed to be same as in year 2010 for the respective technologies in the Business–As–Usual Scenario.

3.8.4 Ambitious Scenarios for the Industrial Sector

To estimate the energy consumption from the industrial sector under ambitious scenarios, a bottom-up approach is initially followed wherein energy consumption has been calculated separately for cement, steel and other industries. Fuel consumption thus obtained from these three industries is then aggregated to arrive at the energy use from the industrial sector.

3.8.4.1 Steel Sector

The specific electrical energy consumption for Malaysian steel plants using scrap as the raw material to produce steel is 607 kWh/t (Audit Report of Steel Sector, 2001). In the ambitious scenario it has been assumed that the specific electrical energy consumption would improve by 10% by 2030 and would reach 547 kWh/t in 2030.

⁹⁷ Due to lack of data, RESID for cement sector (cement dry process) and other industries could not be considered (assumed to be 0).

3.8.4.2 Cement Sector

In the ambitious scenario it has been assumed that the specific electrical energy consumption would improve and would reach the Indian standard by 2030. The specific electrical energy consumption would decrease from 87 kWh/t in 2010 settling at 79 kWh/t in 2030. With regard to the specific fuel consumption for the cement sector, it is expected to reduce from 3.76 GJ/t in 2010 to 2.2 GJ/t in 2030. It also assumed that the specific thermal energy consumption for the cement sector would improve from existing 984 kcal/kg of clinker in 2010 to 726 kcal/kg of clinker by 2030 with 75% as the clinker/cement ratio⁹⁸.

3.8.4.3 Other Industries

In the ambitious scenario, it has been assumed that there would be a 10% reduction in the energy consumption for each of the fuels from 2012 till 2030. Under the energy audits conducted under MIEEIP project, potential energy savings for the industries averaged 23% if the recommendations from the energy audit were implemented. The reason why a 10% reduction has been assumed is that most of these industries are in the SME sector and establishments under SME face barriers such as limited access to finance and energy efficient technology. It is anticipated that bringing in new and efficient technology would result in lower energy consumption. Since these energy audits were conducted almost a decade back in early 2000's, it is presumed that some of the measures for energy efficiency would already have been incorporated in the SME sector and a modest figure of 10% energy savings has been assumed in the AMB scenario.

The results of the Business-As-Usual and the ambitious scenarios are discussed in Chapter 3.11 of this report.

3.8.5 Emissions from Industrial Processes

Process emissions from the industrial sector represented 6% of overall GHG emissions in Malaysia. Emissions from the production of cement and steel accounted for 90% of the total CO₂ emissions from industrial processes in 2000 (NC2, 2011).

Cement production is energy-and raw-material-intensive process that results in the generation of CO₂ from both the energy consumed in making the cement and the chemical process itself. Out of the total CO₂ emitted by the industrial processes in 2000, 68% of CO₂ was emitted from the cement sector alone⁹⁹. CO₂ emissions from cement production are estimated by applying an emission factor, in tonnes of CO₂ released per tonne of clinker produced, to the total amount of clinker produced. It is important to emphasise over here that the share of clinker in cement production i.e. clinker/cement ratio in Malaysia stands at 0.91 for 2010. This high share of clinker in cement production in Malaysia offers an opportunity to reduce the emissions by the manufacture of blended cements (decreasing the use of clinker and increasing the share of other raw materials). Table 3.8.5 shows the emissions from industrial processes in the reference scenario till 2030.

⁹⁸ It is assumed that there would be efficiency improvements in the cement productions of Malaysia and specific energy consumption would confirm to the Indian standards by 2030.

⁹⁹ NC2, 2011

Assumptions for the BAU:

- i. The emission factor for steel production is 0.75 (tonne of CO₂ /tonne of product). Steel production is estimated and multiplied with the emission factor to estimate the total emissions from steel sector.
- ii. The emission factor for clinker in cement is 0.51 (tonne of CO₂ /tonne of clinker) and it is assumed that installed capacity of clinker is equal to the total clinker produced in the country. It is assumed that in the future till 2030, the clinker/cement ratio would remain at 0.91. In order to calculate the clinker production in Malaysia, cement production is estimated and then multiplied with the 0.91 (clinker/cement ratio). After the estimation of clinker production, it is multiplied with the emission factor for clinker in cement to arrive at the CO₂ emissions from the cement sector.
- iii. Since emissions from cement and steel constitute 90% of the total emissions from the industrial processes, the sum of emissions from cement and steel is divided by 0.9 to arrive at the total emissions from industrial processes.

Table 3.8.5: Emissions from industrial processes in the BAU scenario (MtCO₂ eq.)

Year	Clinker		Steel		Clinker & steel	Total emissions ¹⁰⁰
	Production (Mt)	Emissions (MtCO ₂ eq.) (a)	Production (Mt)	Emissions (MtCO ₂ eq.) (b)	Emissions (MtCO ₂ eq.) (c) = (a) + (b)	Emissions (MtCO ₂ eq.) (d) = (c)/0.9
2011	18.61	9.58	6.22	4.67	14.25	15.83
2015	21.33	10.98	7.60	5.70	16.69	18.54
2020	25.30	13.03	9.78	7.33	20.36	22.26
2025	30.00	15.45	12.57	9.43	24.88	27.64
2030	35.59	18.33	16.15	12.12	30.44	33.82

Source: TERI Estimates, 2012

Table 3.8.6 shows the emissions from industrial processes in the ambitious scenario in MtCO₂ eq. In the ambitious scenario, all the assumptions for the BAU apply except for the assumption for clinker/cement ratio. It has been assumed that Malaysia would produce blended cement in the future that would bring down the clinker/cement ratio from 0.91 in 2010 to 0.75 in 2030 in the AMB.

¹⁰⁰ Emissions from cement and steel constitute 90% of the total emissions from industrial processes. The sum of the emissions from cement and steel is divided by 0.9 to get the total emissions for the industrial processes.

Table 3.8.6: Emissions from industrial processes under AMB scenario (MtCO₂ eq.)

Year	Clinker		Steel		Clinker & steel	Total emissions
	Production (Mt)	Emissions (MtCO ₂ eq.) (a)	Production (Mt)	Emissions (MtCO ₂ eq.) (b)	Emissions (MtCO ₂ eq.) (c) = (a) +(b)	Emissions (MtCO ₂ eq.) (d) = (c)/0.9
2011	18.61	9.58	6.22	4.67	14.25	15.83
2015	20.33	10.47	7.60	5.70	16.17	17.97
2020	23.07	11.88	9.78	7.33	19.21	21.35
2025	26.13	13.46	12.57	9.43	22.88	25.42
2030	29.33	15.10	16.15	12.12	27.22	30.24

Source: TERI estimates, 2012

Figure 3.8.8 shows the emissions reduction from Industrial Processes in the ambitious scenario compared to the BAU scenario.

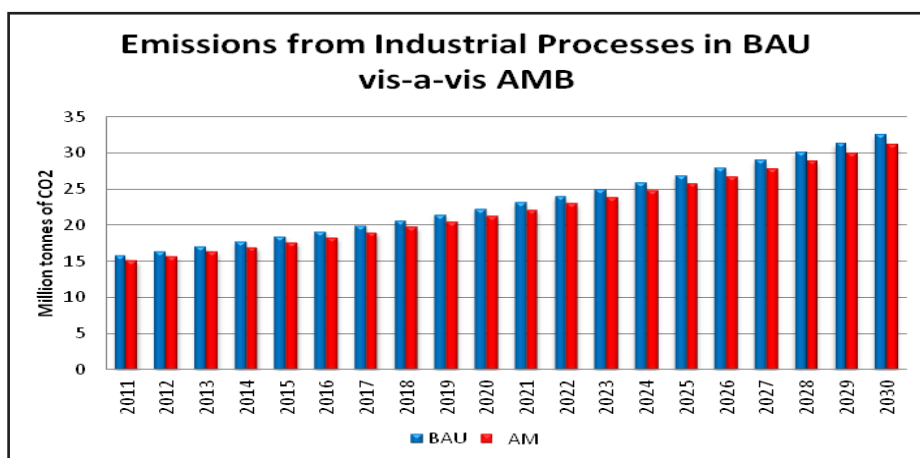


Figure 3.8.8: Emissions from industrial processes in BAU versus AMB

Source: TERI estimates, 2012

The major factors affecting energy efficiency of industrial plants are: choice and optimization of technology, operating procedures and maintenance, and capacity utilization that is the fraction of maximum capacity at which the process is operating. While existing technologies can significantly reduce industrial GHG emissions, new and lower-cost technologies will be needed to meet long-term mitigation.

Many studies (US DOE, 2004) have shown that large amounts of energy can be saved and CO₂ emissions avoided by strict adherence to carefully designed operating and maintenance procedures¹⁰¹. With improvements in energy efficiency, it is projected that Malaysia can save an average of 23% in energy consumption from the industrial sector alone that translates to RM 85 million per year off from the energy bill ¹⁰². This could be simple zero-cost measures such as switching off equipment when not in use to high-cost measures involving the use of new technologies. Low-cost recommendations involve carrying out measures such as recovery of the heat waste from the flue gas stack and the boiler condensates, using as much day-lighting as possible for the factories, and ensuring that the steam systems are well insulated. High-cost recommendations involve implementing measures that incur substantial investments; which normally includes putting up or replacing old equipment or technologies with new and more efficient ones, and improving existing processes with more state-of-the art processes.

Achieving sustainable development will require the implementation of cleaner production processes without compromising employment potential. Large companies have greater resources, and usually more incentives, to factor environmental and social considerations into their operations than small and medium enterprises (SMEs), but SMEs provide the bulk of employment and manufacturing capacity in many developing countries. In 2009, there were 28,840 SMEs in Malaysia, which represented 94.2% of the total establishments in the industrial sector. Also, the total number of employees engaged by SME's establishments was 648,458 workers or 38.3% of total employment in industrial sector (1,693,154 workers) in 2009. In terms of value added, SME contributed to 24% of the total GDP of the industrial sector in 2009 (Department of Statistics, 2010). Since SMEs in Malaysia play such an important role in the Malaysian economy and face barriers such as limited access to energy efficient technologies and practices, one of the top priorities should be focusing on SME development and implementing measures that bring in new technologies that enhance their competitiveness and result in energy saving.

Energy efficiency programmes focus on energy savings and optimal utilisation of the limited economic resources. The specific energy consumption (SEC) shows the energy consumption per unit of production and is considered as a benchmark for comparing energy efficiency standards. As SEC is dependent on total energy consumption and production figures, it is certainly influenced by type of fuel used, production processes and energy consuming machinery (i.e. their efficiency). The specific energy consumption for cement production in Malaysia has been increasing for the last three years (Table 3.8.3). Producing blended cements would result in lowering energy consumption and also reducing process related emissions in the cement sector.

Slowing the increase in the harmful impacts of industrial production on the environment requires boosting industrial energy efficiency. Awareness on energy efficiency is a key factor that will encourage an industry to implement energy efficient practices.

¹⁰¹ Industry in Climate change 2007: Mitigation, Contribution of Working group III to the Fourth Assessment report of the Intergovernmental; Panel on Climate change

¹⁰² MIEEIP 2008

3.9 Residential and Commercial Sector

3.9.1 Energy Consumption in Residential and Commercial Sectors

The residential and commercial sectors together are the third largest consumer of energy in Malaysia after the industrial and transport sectors. While the share of energy consumed by the residential and commercial sector has remained between 12-14% of the total energy consumption, growing at about 7.4% per annum from 2001-2007. In the commercial sector, in absolute terms it has increased from about 2,430 ktoe in 2001 to about 3,730 ktoe in 2007; and, in the residential sector, it has increased from about 1,630 ktoe to 2,500 ktoe in 2007.

Energy consumption in commercial sector is increasing at a faster rate than consumption in the residential sector. Residential energy consumption has increased at 5.8% per annum during 2001-2007, while energy consumption in the commercial sector has increased at 8.5% during the same period.

3.9.2 Residential Sector

The residential sector accounted for about 5.5 % of the total energy consumption and about 20.8% of Malaysia's electricity consumption in 2007 (Peer Review on Energy Efficiency, APEC Energy Working Group, 2011).

Figure 3.9.1 shows the fuel mix over time in the residential sector. During 1990-2010, the share of electricity in the residential sector has increased from about 55% to around 63%, kerosene has decreased from 12% to 2%, share of LPG has increased from about 30% to 35% and the rest is natural gas.

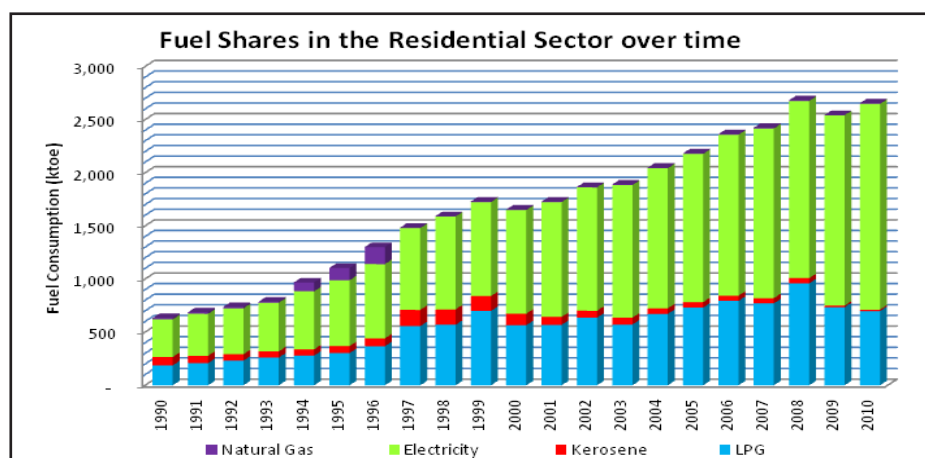


Figure 3.9.1: Fuel mix in residential sector

Source: NEB, 2010

The average residential energy use per household has increased on average from 331kgoe/household in 2001 to 419 kgoe/household in 2007 based on energy consumption data of the residential sector. By year 2030, more than 70% of the population is expected to be in urban areas as compared to about 63% currently (as of 2010 figures). Thus, factoring for the increase in population, rising per capita income and increasing rate of urbanisation, there is bound to be a greater amount of energy consumption given that the minimum standard of living will be higher than it is currently.

As per Business-as-Usual estimates, electricity consumption would increase from 34.61 TWh in 2020 and 41.79 TWh in 2030. It is likely however, that households with higher incomes would have much higher levels of energy consumption levels as compared to the lower income households. A TNB estimate of average electricity demand by household level, though slightly dated, exists by way of information on the level of variation across income classes as indicated in Figure 3.9.2. Though the electricity consumption may not have changed much across income classes, but over time with a change in the distribution of population across incomes (Table 3.9.1) and increasing GDP, an increase in overall electricity consumption is inevitable.

The total electricity consumption incorporate changes in demography and other socio-economic characteristics. Households with monthly income below RM 1,000 have been classified as low income households; with monthly income between RM 1,000 and RM 4,000 as middle income households; and, with monthly income above RM 4,000 as high income households. Table 3.9.1 gives a profile of demographic distribution based on which estimates have been generated.

Table 3.9.1: Transition of population across income classes

Year	% of population		
	Low	Medium	High
2005	32%	39%	29%
2015	20%	40%	40%
2020	19%	41%	40%
2030	17.5%	42%	40.5%

Source: EPU, 2012

At this juncture, the overall energy projection estimation for the sector is based on past trends. The following relationship has been established by regressing total energy consumption (Y) over the number of households (X):

$$Y = (-2432.98) + (0.828)*X$$

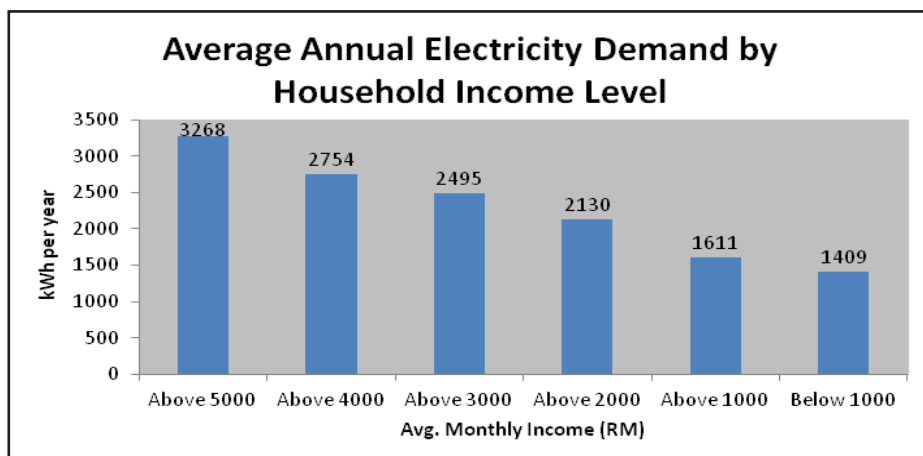


Figure 3.9.2: Estimate of average annual electricity demand by household income level
Source: Malaysia DANISH Environmental Cooperation, 2005

Accordingly, the total energy consumption projections based on this relationship for the residential sector is reflected in Figure 3.9.3.

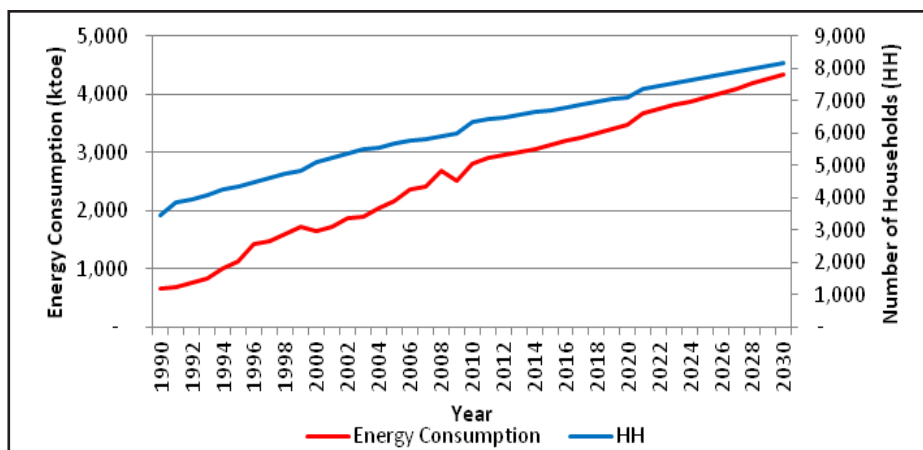


Figure 3.9.3: Projected energy consumption in the residential sector and number of households

Source: TERI Analysis, 2012

As indicated in Figure 3.9.3, the rate of change of energy consumption in the residential sector is much faster than the rate of growth of households. This indicates that households are consuming energy much more intensively over time. This may be on account of the shift of population towards higher level of expenditure and better standards of living (Table 3.9.1). Thus, there is a need for strict measures of energy efficiency improvement to be introduced so as to meet the 40% emission reduction target for Malaysia. For the purpose of the analysis, past trends of energy consumption in the residential sector and factors such as growth in number of households and the distribution of population across income groups have been taken into consideration.

In order to identify in detail the potential for emission reduction in the residential sector, a thorough analysis of the important parameters was carried out so as to ensure an accurate estimate of potential reductions, thus facilitating sound policy and decision-making.

Population Growth

The expected growth rate of population is around 1.14% per annum for the period 2011 - 2035. This is an issue of key concern for Malaysia as with increasing population pressure, the energy needs will also increase. With most of the energy use in the residential sector coming from electricity use, the largest potential for emission reduction also lies in the ability to ensure efficient use of electricity. The changing demographic structure, changes in income and its impacts on energy needs have been outlined in Chapter 2.

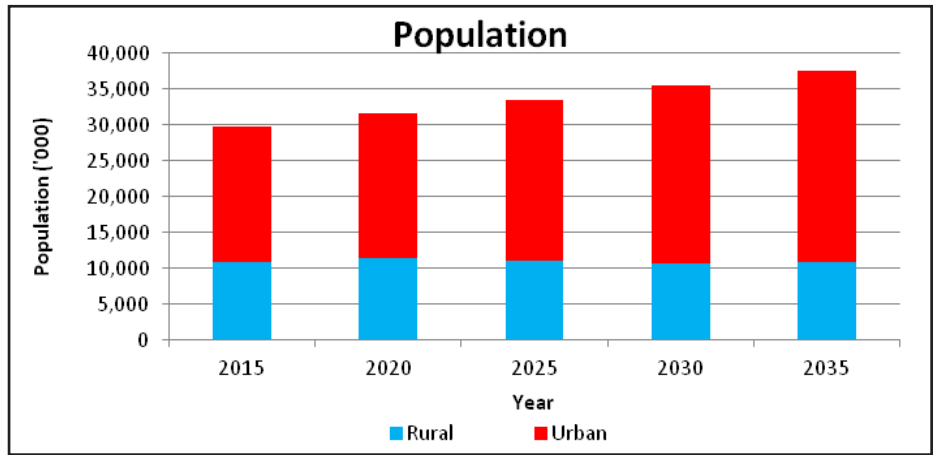


Figure 3.9.4: Population growth

Source: EPU, 2012

Gross Domestic Product (GDP)

With targets towards a higher per capita income, the Economic Transformation Programme and other plan documents outline a GDP growth of 6% per annum up to 2020 and 5% per annum subsequently by 2030 which implies that the per capita GDP would be almost double or more as mentioned in Chapter 2. This has considerable implications on energy use in the residential sector.

Energy Consumption Across Different Population Strata

Based on inputs from the Energy Commission and other government agencies as well as surveys on energy consumption instituted by different stakeholders, energy consumption has been characterized across rural and urban households and these figures have been used for estimating total energy consumption. In the residential sector, electricity contributes the most in terms of energy consumption. Thus, the potential for emission reduction in the residential sector lies in the reduction of electricity usage or in other words, efficient and judicious use of electricity.

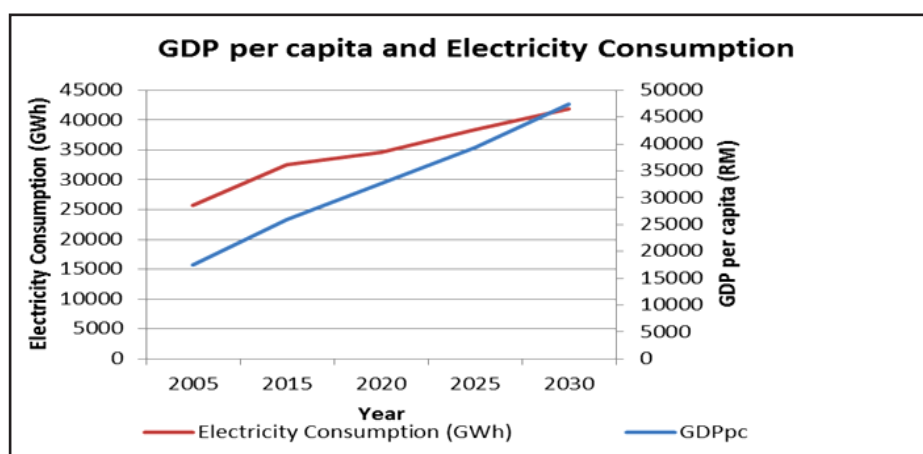


Figure 3.9.5: Projected electricity consumption in residential sector and GDP

Source: TERI Analysis, 2012

Also, based on the relationship between GDP per capita and electricity consumption in Malaysia (Figure 3.9.5), electricity consumption could increase to around 33,000GWh (~2,750ktoe) in the residential sector by 2020 and to about 42,000 GWh by 2030 in a Business-as-Usual (BAU) scenario. This is obviously not a sustainable trend and the scope for efficiency improvement needs to be ascertained to reduce the overall electricity requirement.

While a first assessment of future energy and electricity requirement in the Residential sector has been carried out, based on consultations with experts in Malaysia, a detailed roadmap analysis of the options for emission reduction have been formulated.

In order to estimate the potential for energy savings in the residential sector, two other scenarios were formulated, namely – BAU scenario and ambitious scenario. Table 3.9.2 gives an overview of the different scenarios.

Table 3.9.2: Overview of scenarios for residential sector

	Parameters	BAU Scenario	Ambitious Scenario
Urban	Solar Potential (mainly water heating)	20% of potential households (middle income and high income)	50% of potential households (middle and high income)
	Energy Efficient Appliances	40% of all households	75% of all remaining households
	Green Buildings ¹⁰³	New stock from 2012 onwards (70% Certified, 10% Silver, 15% Gold, 5% Platinum)	New stock from 2012 onwards (50% Certified, 20% Silver, 25% Gold, 10% Platinum)
Rural	Solar Potential (both water heating as well as for powering electrical appliances)	30% of potential households (8% by 2020 and 30% by 2030)	50% of potential households (30% by 2020 and 50% by 2030)
	Energy Efficient Appliances	30% of potential households	50% of potential households

Based on the scenarios, the potential for emission reductions were estimated. The following sections describe the technology assumptions and estimated emissions reductions over time.

Technology Assumptions

In the residential sector, energy use can be broadly categorized into lighting, cooking, air-conditioning, refrigeration, water heating and others.

Lighting

In the case of lighting, it is assumed that households use incandescent bulbs, fluorescent lights, CFL bulbs and LED bulbs. For the BAU scenario, it has been assumed that 40% households use incandescent bulbs, 40% use fluorescent lights, and the remaining 20% use CFLs or LEDs for lighting. For the purpose of analysis, the fluorescent tubelight is assumed to be twice as efficient as the incandescent bulb; the CFL bulb is 4 times as efficient as the incandescent bulb; and, the LED bulb is 8 times as efficient as the incandescent bulb.

Moreover, the total potential monetary savings are about RM 141 million for 25% retrofit, RM 282 million for 50% retrofit and 423 million 75% retrofit for 5,000 operation hours of efficient lighting. It can be concluded that consumers should be encouraged to use efficient lighting in their household (Mahlia, et. al, 2004).

¹⁰³ Green Buildings are classified into 4 categories namely Platinum, Gold, Silver and Certified, with Certified being the minimum and Platinum the best. Further details are provided in Table 3.9.6

Cooking

For cooking, it has been assumed that households use LPG, Natural Gas and electricity. The efficiency of the gas stoves has been assumed to be 65% while the electric stove efficiency has been taken at 70%.

Cooling

For cooling the house, options available are either by better insulation or using air-conditioning. For air-conditioning, two types of air conditioners have been considered: conventional and efficient. It has been assumed that with time, technology improvements would lead to an increase in efficiency of the conventional air-conditioner by about 25% in 2030 while the efficiency increase for the efficient air-conditioner would be about 35% by 2030 (Energy Commission, Malaysia, 2011). Since, the air-conditioners being sold in the Malaysian market are complying with the electrical equipment labelling programme; technology improvement is bound to occur.

Refrigeration

Refrigeration is a necessity when it comes to daily household use. Refrigerators are also covered under the electrical equipment labelling programme, and based on the technology development in the market over the past few years; the assumption is that by 2030 the standard refrigerator would improve its efficiency by 25% while the efficient refrigerator would improve its efficiency by 35% (Energy Commission, Malaysia, 2011).

There are many advantages for Malaysia in implementing an energy efficiency standard for refrigerator-freezers. The programme will encourage manufacturers to produce energy efficient products, which will increase the competitiveness in the local and international market. The consumers will pay higher prices for appliances, which will be offset by lower electricity bills. Once the standard is implemented, inefficient products will be pushed out from the market. The standard must be periodically revised to continue progress in improving appliance efficiency. The standard indirectly also reduces environmental pollution. This could result in a saving of about 8,000GWh over a 10 year period (Mahlia, et.al, 2003).

Water Heating and others

Application of Solar-PV has been considered for water heating. Some houses have obstacles on its roof, which make solar thermal not suitable. A rough evaluation has assumed that about 1/5 of the residential buildings are not suitable due to architectural constraints. Another 1/3 of TNB's residential clients live in small villages across the country and they are unlikely to install solar thermal (Malaysian Danish Environmental Cooperation Programme, 2005).

3.9.3 Commercial Sector

The commercial sector in Malaysia includes a diverse range of buildings in the public and private sectors. It comprises establishments that occupy an office block, shops, -warehouses, restaurants, schools, hotels, boarding house estates, ports, railway installations, military, installations and hospitals. This sector consumes around 7.8% – 10.4% of the energy and around 32.3% – 34.6% of electricity in Malaysia (NEB 2010), with the share of commercial sector in energy consumption growing by five times in the past three decades. Figure 3.9.6 represents the trend in energy consumption in the commercial sector during 1980-2010.

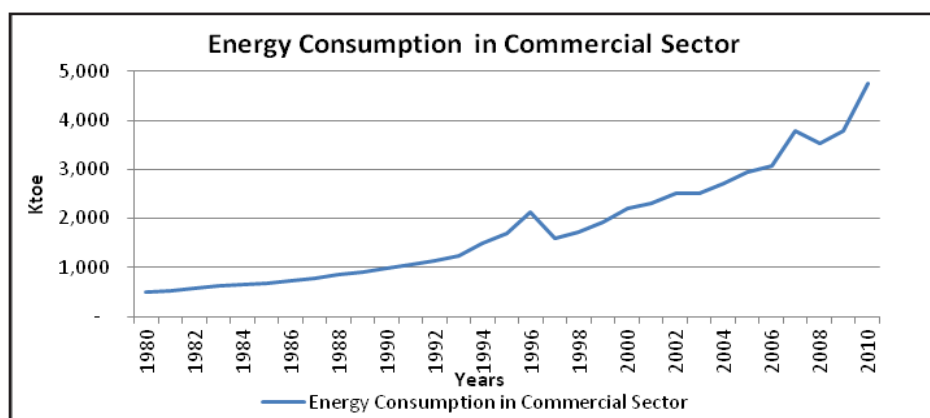


Figure 3.9.6: Energy consumption in commercial sector

Source: NEB, 2010

There is a high positive correlation between energy consumption and growth in the commercial sector (as represented by growth in GDP services). Based on this relationship and projections of GDP in services sector, energy consumption in the commercial sector is projected till 2030, as depicted in Figure 3.9.7.

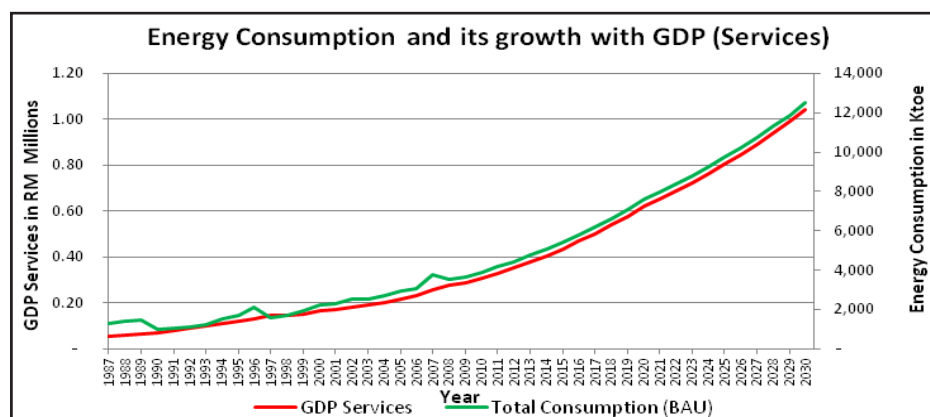


Figure 3.9.7: Energy consumption and its growth with GDP (services)

Source: TERI analysis, 2012

3.9.3.1 Energy Mix in the Commercial Sector

As indicated in Figure 3.9.8, over the years, the composition of the energy-mix has changed from being driven by LPG, kerosene and electricity to being driven largely by electricity. The share of electricity has increased from about 40%-44% to about 64%-70% during 1980 and 2010, the share of kerosene has decreased from 30%-40% to a near negligible level, and the share of LPG has more or less remained constant at about 12%. Diesel and natural gas have been used intermittently over time.

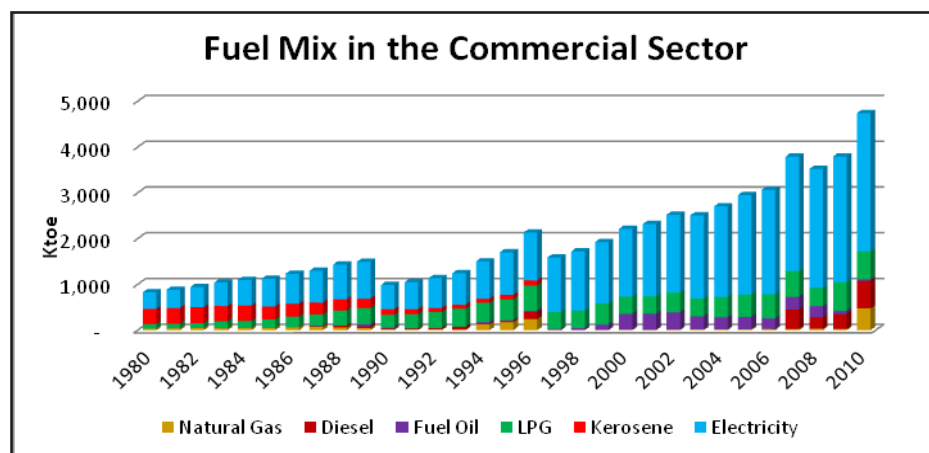


Figure 3.9.8: Fuel mix in the commercial sector

Source: NEB, 2010

Some estimates indicate that, around 64% of electricity in the commercial sector is used for air conditioning, while the rest is consumed for lighting and by general equipment (Chan, 2004). Also, the share of electricity consumed by air-conditioning vis-à-vis other end-use demands in the commercial sector is extremely high when compared to that in other countries such as Thailand, Indonesia, etc.

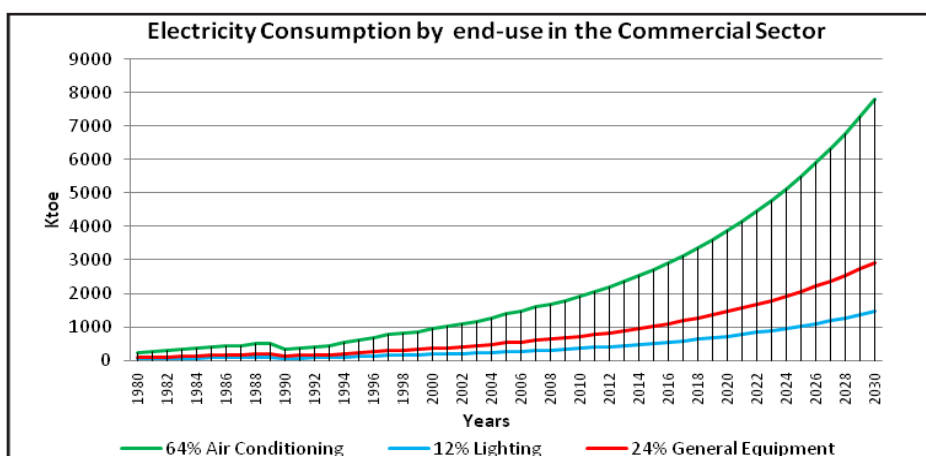


Figure 3.9.9: Electricity consumption by end-use in the commercial sector

Source: TERI estimates, 2012 adapted from Chan Seong Aun, 2004

Table 3.9.3: Typical percentage of electricity consumption for commercial sector in each selected country

Country	Percentage of Electricity Consumption (%)			Reference
	Air-conditioning	Lighting	General Equipment	
Malaysia	64	12	24	Chan Seong Aun (2004)
Indonesia	51	14	26	Rizka et al. (2005)
Thailand	46	31	23	www.aseanenergy.org (20/01/2006)
Singapore	59	7	34	www.bca.gov.sg (20/01/2006)

Source: TERI estimates, 2012

Assuming past trends of electricity consumption, and keeping the share of air-conditioning, lighting and other equipment in electricity consumption constant at the 2007 level, Figure 3.9.9 reflects the future electricity requirements in the commercial sector till 2030. It is assumed that the proportion of air-conditioning to be at the 2007 level as the current scenario reflects that most commercial establishments already have some cooling system in place, either through the district cooling system or individual air-conditioners. Thus, though the services sector is expected to rise rapidly, the energy consumption will certainly increase manifold but the proportion of air-conditioning is not expected to change much.

Analysis of the commercial sector

The following section describes the energy consumption and energy efficiency trends in the commercial sector based on the inputs received during stakeholder consultations. The services demanded by buildings – lighting, air conditioning, water heating, electronic equipments, computing, refrigeration, and cooking - require significant energy use and their energy consumption has been growing over time. Thus improvements in technologies and practices in lighting, air conditioning, building controls, appliances and the whole building design and construction would lead to significant reduction in the energy intensity.

Based on past trends, the energy consumption for the commercial sector was estimated accounting for the growth in the services sector. Given the constraints of data, the potential reductions in energy consumption have been estimated for four major commercial establishments namely, office buildings, shopping complexes, hospitals and hotels.

Over the years there has been significant growth in the commercial floor space as the overall economic activity has increased and thus the GDP of the economy. From 1980 to 2010, GDP grew five times and consequently, though not perfectly correlated, the absolute amount of commercial floor-space grew roughly around 50% over the same period. For the purpose of the analysis, to estimate the commercial floor space, the services component of GDP has been used.

With the growing services sector, there has also been a 12.5% increase in the area under shopping complexes and a 7.5% increase in office spaces. This means that the energy requirement will also grow with this trend.

The potential emissions reduction can be formulated into three scenarios namely, BAU scenario, ambitious scenario 1 and ambitious scenario 2. The scenarios are outlined in Table 3.9.4.

Table 3.9.4: Overview of scenarios for commercial sector

Parameters	BAU Scenario	Ambitious scenario 1	Ambitious scenario 2
Building Efficiency (Green Building Index)	40% Certified 20% Silver 30% Gold 10% Platinum	20% Certified 30% Silver 30% Gold 20% Platinum	20% Certified 20% Silver 30% Gold 30% Platinum
Renewable Energy (Solar power)	5% of the total floor area	7% of the total floor area	10% of the total floor area
Efficient Equipment	30% of the buildings adopt efficient appliances	50% of the buildings adopt efficient appliances	75% of the buildings adopt efficient appliances

Source: TERI analysis, 2012

Three options have been considered for the analysis: green buildings, potential of renewable energy (solar power) and introduction of efficient equipments/appliances. It has been assumed that new buildings that will be constructed from now onwards would be registered as green building. The performance of the Malaysian building sector would improve and thus contribute to significant emissions reductions over time. It has been estimated that the total potential of the commercial sector for solar energy is only 5% of the total area and would result in an improved efficiency of 15% in terms of energy consumption. The application of solar energy as an option can be divided into two categories: solar thermal application and photovoltaic technologies (MEGTW, 2011). Finally, it has also been assumed that as more equipment come under the electrical equipment labelling programme, it would help reduce emissions further.

In the BAU Scenario, it has been assumed that at least 40% of the buildings are certified under Green Building Index, 5% area is under solar installations (MEGTW, 2011) and 30% of the buildings adopt energy efficient appliances by 2030. In the ambitious scenario 1, it is assumed that more buildings will be rated under silver, gold and platinum category and hence increasing the efficiency, 7% of the area would be under solar installations and 50% of the buildings will adopt energy efficient appliances. In the ambitious scenario 2, it has been assumed that 30% of the building stock would acquire platinum rating with the highest energy efficiency, 10% will be the potential area under solar energy and 75% of the buildings would use energy efficient appliances.

It has been found that huge amount of energy and costs can be saved and emissions can be reduced by introducing different energy savings options in the commercial sector. It was found that the predicted energy savings for different energy-saving strategies can be achieved within a viable payback period, though it should be recognized that this estimation has been demonstrated only for a small number of office buildings in Malaysia. Nonetheless, there are other commercial sub-sectors where significant savings of energy and costs can be made and associated emissions can be reduced by adopting different energy-saving measures. Among the strategies analysed, housekeeping, raising thermo-stat temperatures, and standby mode do not require any additional investment to implement, whereas replacement of incandescent with CFL and the use of insulation, whose payback period is short compared to the life span, are found to be economically viable.

Table 3.9.5: Energy and costs savings for different energy saving measures for commercial sector

Energy Savings Options	Costs Savings per life span (USD)	Reference
Raising thermostat set point temperature	1,118,528	Yamtraipat, et. al, 2006
Housekeeping	490,560	Uchiyama, 2002
CFL	6,208	Saidur, 2009
Advanced glazing	1,165,120	Chirarattananon and Taweeku, 2003
Insulation	932,096	Chirarattananon and Taweeku, 2003
Stand by	245,312	Saidur, 2009

The analysis of the commercial sector also brings out certain gaps which if addressed could lead to a more comprehensive analysis and thus facilitate better policy planning. The gaps are outlined in the following points:

- i. A holistic view of the building sector is required to completely identify the potential range of emission reduction opportunities.
 - It is essential to consider the future building construction, use and location.
 - There is a need to differentiate between the energy consumption of small commercial buildings and large commercial complexes.
- ii. An integrated approach is needed to address emissions from the Malaysian building sector.
 - One that coordinates with the technical and policy solutions - integrating green building with smart-growth concepts.
 - The current building practices are yet to make the transition towards green buildings. Hence, vigorous market transformation and programmes are critical to success.

3.9.4 Review of Policies Influencing Residential and Commercial Sectors

Electrical Equipment Labelling Programme

The Malaysia Electrical Appliance Labelling Programme was introduced in 2005 and covers several items namely the refrigerator, air-conditioner, television, motor, lamp and fan. The labelling programme is being expanded to cover more electrical appliances. Appliances are labelled on a scale of five (5) stars with three (3) stars as the average. The more stars an appliance gets, the higher its efficiency is.

The impact of the labelling programme in terms of reduced energy intensity in the household sector -does not appear to be significant from the existing available data.

The penetration of efficient appliances needs to be a key priority area. The residential energy use is basically a disaggregation of a typical home where about half of the energy used goes to heating and cooling while the other half is in base load, which includes refrigerators, lighting, and other appliances.

Energy pricing is a crucial parameter which is acting as a barrier to the success of the programme. Highly subsidized and low energy prices are a disincentive for households to switch to energy efficient appliances. The marginal increase in electricity consumption from using appliances that may not be efficient does not entail much cost thus resulting in low penetration of star-rated appliances.

The other factor that impacts the success of the energy labelling programme is the fact that it is currently a voluntary requirement. This means that only select products and manufacturers are complying with efficiency criteria. This also results in efficient appliances to remain costlier due to lack of competitive pricing. If the equipment labelling programme was to be made mandatory, it would mean that all appliances and manufacturers would have to comply with the labelling criteria thus ensuring a level-playing field for all manufacturers and simultaneously bringing the price of labelled appliances down as more players enter the market.

Awareness creation will play a key role in ensuring that the labelling programme is understood well by the consumers and they realize the benefits of using energy efficient appliances. The consumers need to be made aware of the potential cost-savings from use of labelled appliances and as cost-savings will be realized from the day of switching to efficient technology, it will be a tangible result for consumers to see and adopt.

Auditing and Retrofitting Existing Buildings into Energy Efficient Buildings

There has been a significant effort to audit and retrofit existing residential buildings and apartment complexes as well as commercial establishments under the Energy Efficiency Master Plan, so as to identify the potential for energy efficiency in this sector. This exercise has to be taken up in tandem with the energy labelling programme as once the potential areas of energy efficiency are identified, they need to fit with appliances which are energy efficient and rated under the labelling programme.

For analysis of the energy consumption, it is important to distinguish between new and existing buildings. New construction can be designed to incorporate and qualify for the green building index while the existing buildings would go for retrofitting and upgrading the efficiency and operation of their lighting and air-conditioning devices and thus providing opportunity to significantly reduce emissions.

The government of Malaysia has taken several pro-active actions in promoting energy efficiency through demonstration buildings including the Kuala Lumpur Securities Commission located at Bukit Kiara, Kuala Lumpur, Ministry of Energy, Green Technology and Water (MEGTW) located at Putrajaya, Malaysia Green Technology Corporation (MGTC) located at Bangi, and the Energy Commission's Diamond Building. These demonstration buildings could encourage private sector to also construct and design low energy buildings.

An audit of existing buildings would need a large resource of energy managers and necessary infrastructure in terms of training should be provided. Apart from rebates on labelled appliances (currently applicable to refrigerators and air-conditioners), monetary incentives can also be provided to households who achieve a certain level of energy efficiency.

Within the commercial buildings, lighting and air conditioning account for a significant portion of energy consumption and therefore energy efficient lighting and conditioning technologies have been targeted under many efficiency programmes. An example of advanced energy saving technology in the air conditioning is the adoption of variable speed drivers which lead to a minimum of 7%-8% reduction in energy consumption (Saidur, 2011).

There has also been a policy indication of a shift towards CFLs and LEDs for lighting in place of incandescent bulbs. There is potential in both residential and commercial sector to replace the existing incandescent bulbs with CFLs/LEDs. As per the Energy Efficiency Master Plan, Malaysia hopes to phase out all incandescent bulbs by 2014. While this is being implemented, the impacts on industry and employment should also be considered, i.e. while incandescent bulb manufacturers will go out of business, it will impact both industry and labour employment if there is large-scale domestic manufacturing. A planned phasing out of incandescent bulbs with CFLs and LEDs will help. Also, a direct transition to LEDs will be much better in terms of cost-effectiveness as well as energy efficiency.

Green Building Certification (Green Building Index, GBI)

With the realization that buildings contribute significantly to the greenhouse emissions, the Green Building rating system was initiated in the 1990s with BREEAM (UK, 1990) and later LEED (USA, 1996) so as to reduce their energy consumption and thus their impact on the environment.

A comparison of the existing Green Rating tools available worldwide today shows that all these rating systems were designed for temperate climate zones. Some better known ones include UK's BREEAM, USA's LEED, Japan's CASBEE and Australia's GREENSTAR. The Malaysian Green Building Index or GBI is the only rating tool for the tropical zones other than Singapore Government's GREENMARK.

GBI in Malaysia was developed by PAM (Malaysian Institute of Architects) and ACEM (the Association of consulting Engineers Malaysia) in 2009. The GBI is a comprehensive rating system for evaluating the environmental design and performance of Malaysian building based on the six main criteria of energy efficiency which have been outlined earlier during the detailing of the residential sector. The index has been designed to suit the Malaysian tropical weather, environmental context, cultural and social needs. The GBI of Malaysia compares well with the rating systems followed by other countries like USA and India (LEED and GRIHA Rating System).

Green buildings are designed to save energy and resources, recycle materials and minimize the emission of toxic substances throughout its life cycle. They also harmonize with the local climate, traditions, culture and the surrounding environment, and are able to sustain and improve the quality of human life whilst maintaining the capacity of the ecosystem at local and global levels.

Currently, almost 250 projects are registered under the GBI. Through the efficient use of resources there are significant operational savings and increase in workplace productivity. Buildings are categorized and certified based on the GBI Malaysia system taking into account following 6 key criteria:

- i. Energy Efficiency
- ii. Indoor Environmental Quality
- iii. Sustainable Site Planning and Management
- iv. Material and Resources
- v. Water Efficiency
- vi. Innovation

The GBI Non-Residential tool evaluates the sustainable aspects of buildings that are commercial, institutional and industrial in nature. This includes factories, offices, hospitals, universities, colleges, hotels and shopping complexes.

Table 3.9.6 gives an overview of the rating system and an indication of the efficiency achieved by different building types in the residential sector.

Table 3.9.6: Green building index

Green Building Index Classification		
Points	GBI Rating	Efficiency Achieved
86+ points	Platinum	65%
76 to 85 points	Gold	50%
66 to 75 points	Silver	40%
50 to 65 points	Certified	20%

Source: PAM, 2012

Solar Potential

Apart from the above energy saving options, Malaysia has a significant potential for installation of large scale solar power panels as well as rooftop installations on both commercial and residential establishments. Malaysia is situated at the equatorial region with an average solar radiation of 400-600MJ/m² per month. Malaysia has high solar energy potential with the daily average solar radiation of 4,000-5,000 Wh/m². The average sunshine duration is in the range of 4-8h/day.

The solar energy application can be divided into two main categories: solar thermal application and photovoltaic (PV) technologies (Mekhilef, 2012). It has been estimated that the total potential of commercial sector for solar energy is only 5% of the total area and results in improved efficiency of 15% in terms of energy consumption (Renewable Energy Scenario, MEGTW, Government of Malaysia).

In the case of the residential sector, there can be either rooftop installations on apartment complexes and individual households (in the urban areas) or there can be decentralised off-grid solar power plants supplying to a group of households (in rural areas).

Towards Effective Energy Efficiency Implementation

Malaysia is all geared towards achieving developed country status. This would lead to high income society and better quality of life resulting in increasing demand of energy.

Achieving energy efficiency is a considerable challenge yet at the same time it is also a critical component in terms of climate change mitigation. Increasing trends in per capita energy consumption can have serious implications for the future. Thus, it is very important to understand some key issues in the residential and commercial sector which would set the motion for further analysis. An ambitious scenario has been formulated to reduce the CO₂ emission from both sectors mainly through energy efficiency, green buildings and solar energy options. This is further detailed in Section 3.11.

The current plan for Malaysia includes two key programmes, namely the Green Buildings Initiative and retrofitting of existing buildings into energy efficient buildings. Both need to be pursued aggressively to achieve the 40% emission reduction target.

The Green Buildings Initiative has relevance to both the commercial and residential sectors. It is necessary to understand the trends in growth of green buildings in the two sectors across Malaysia. The current initiative involves voluntary compliance. The new policy could include compulsory compliance to building standards. A better enforcement of the Provisions on the efficient use of electricity under the Electricity Supply Act 1990 (Amended) 2001 or Act A1116 could help to boost all these energy efficiency initiatives.

It is not only important to have strong policies but it is also critical to ensure that the implementation and design of the policies are in tune with the local conditions and consumer choices.

Malaysia is aware of these needs and thus existing policies are promulgated and utilised to their best through many programmes, including creating awareness among the people, and having more effective regulations for the energy supply and demand management. Various studies have established that substantial energy savings can be achieved in the residential and commercial sectors by adopting energy efficiency options. The success depends upon the government together with the private sector and the public in general.

To run in tandem with the creation of awareness among the energy consumers, the energy efficiency programmes in Malaysia must be fully supported to ensure their effectiveness. As further discussed in Section 3.11, the energy efficiency programmes are suggested to have:

- i. Online resource library for sharing of best practices and knowledge on energy efficiency
- ii. Voluntary rewards programme for manufacturers that reward those project manufacturers that want to create more energy efficiency products
- iii. Regular review of energy pricing “consume more, pay more”
- iv. Minimum Energy Performance Standards (MEPS) and Energy Managers
- v. Energy Service Companies (ESCOs)

The usage of renewable energy as an alternative of energy source for the residential and commercial sector in the long term is also seen as an option to reduce the CO₂ emission. However to see a large transition towards using the renewable energy, in particular solar, the technology must be commercially available at an affordable rate.

3.10 Energy Supply

3.10.1 Overview of Energy Supply

Energy has been universally recognized as one of the most important inputs for economic growth and human development. There is a strong two-way relationship between economic development and energy consumption. On one hand, growth of an economy, with its global competitiveness, hinges on the availability of cost-effective and environmentally benign energy sources, and on the other hand, the level of economic development has been observed to be reliant on the energy demand.

Consequently during the past three decades primary energy supply has been increasing steadily in Malaysia to meet the requirements of economic growth. Primary commercial energy supply of the country has increased from 10.9 million tonnes oil equivalent (Mtoe) in 1980 to 78.3 Mtoe in 2010 at a compound annual growth rate of 7%.

The main sources of primary energy supply in Malaysia in the 1980 were crude oil and petroleum products (76%) followed by natural gas (20%), hydro (4%) and coal (negligible). Over time there has been significant change in the fuel mix. The share of crude oil and petroleum products in the total primary commercial energy supply has declined, while that of natural gas and coal has increased (Figure 3.10.1).

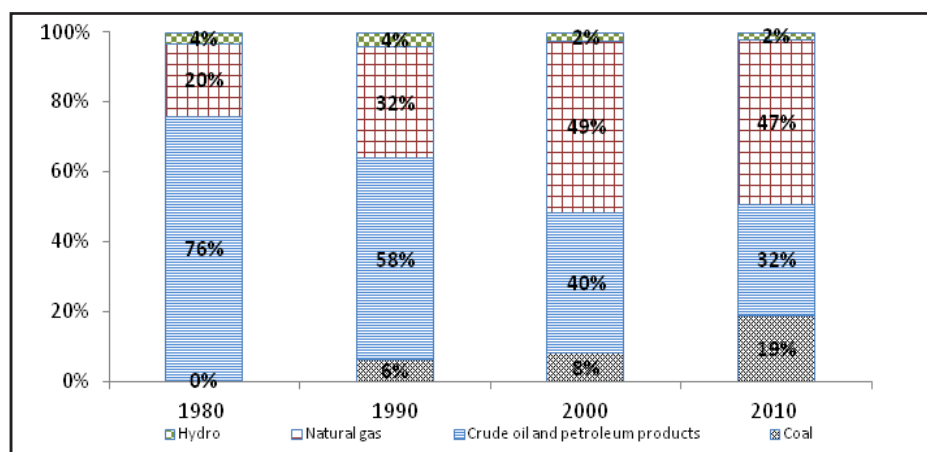


Figure 3.10.1: Primary commercial energy supply mix (1980-2010)

Source: NEB, 2010

Malaysia has always been a net exporter of energy with commercial energy supply of the country greater than the commercial energy use. Total self-sufficiency¹⁰⁴ commercial energy was 149% in 1980 increased to 219% in 1990.

¹⁰⁴ Self-sufficiency is defined as total primary commercial energy consumption as a percentage of total primary commercial energy production in the country

However, since then resource augmentation and growth in energy supply has not kept pace with increasing demand, self-sufficiency declined to 168% in 2000, and further reduced to 136% in 2010 (Figure 3.10.2). If this trend continues, there could be a potential scenario in which Malaysia may eventually become energy deficient.

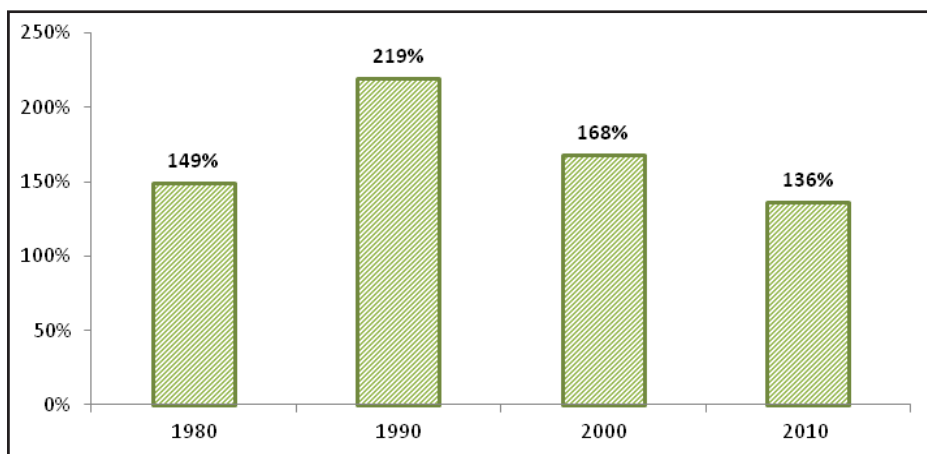


Figure 3.10.2: Total self-sufficiency in commercial energy (1980-2010)

Source: TERI estimates adapted from NEB, 2010

3.10.2 Energy Resource Endowments and Production

3.10.2.1 Oil and Gas

Malaysia's proved crude oil reserve increased from 1.8 billion barrels in the 1980 to 5.9 billion barrels in 2010. Although there have been year-on-year fluctuations, the proved reserves have increased continuously on a decadal basis. In case of natural gas, proved reserves increased from 0.9 trillion cubic metres in the 1980, and to 2.4 trillion cubic meters in 2010 (Figure 3.10.3).

In the short term, reserves of oil in Malaysia have gone up but the production has declined during the past few years. The reserve to production ratio of crude oil has increased slightly from an average of 18 years in the 1980 to 25 years in 2010 (Figure 3.10.3). In case of natural gas, the estimated proved reserves have not increased much, while production of gas increased primarily due to the Four Fuel Policy¹⁰⁵. Consequently, the reserve to production ratio for natural gas has decreased from an average of 379 years in the 1980 to 34 years in 2010.

Malaysia's oil production is expected to be around 700 thousands barrel per day in 2015 and will further reduce to 400 thousands barrel per day in 2030 (IEA, 2009a).

¹⁰⁵ Four Fuel Diversification Policy was adopted in 1981, with the aims of ensuring reliability and securing the supply of energy for electricity. Under this policy, the strategy was designed to reduce the country's over-dependence on oil as a single source of fuel and aims for more balance energy supply mix, i.e. oil, gas, hydropower and coal.

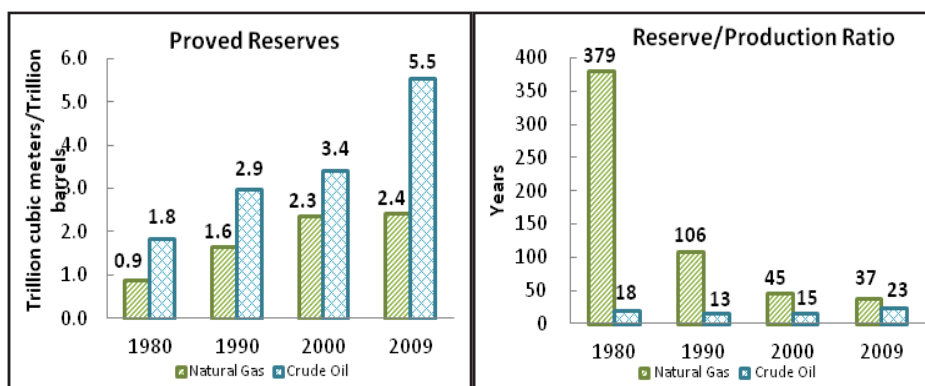


Figure 3.10.3: Proved reserves and reserve/production ratio (1980-2010)

Source: TERI Analysis adapted from NEB, 2010

While the Economic Transformation Programme (ETP) reports decreasing trend of natural gas production (Figure 3.10.4), contrary to this IEA's World Energy Outlook 2009 reports increasing trend. As per World Energy Outlook 2009 natural gas production in Malaysia will be 64 Billion Cubic Metre (BCM) in 2015 and increase to 67 BCM, 71 BCM, and 74 BCM in 2020, 2025 and 2030 respectively (IEA, 2009a).

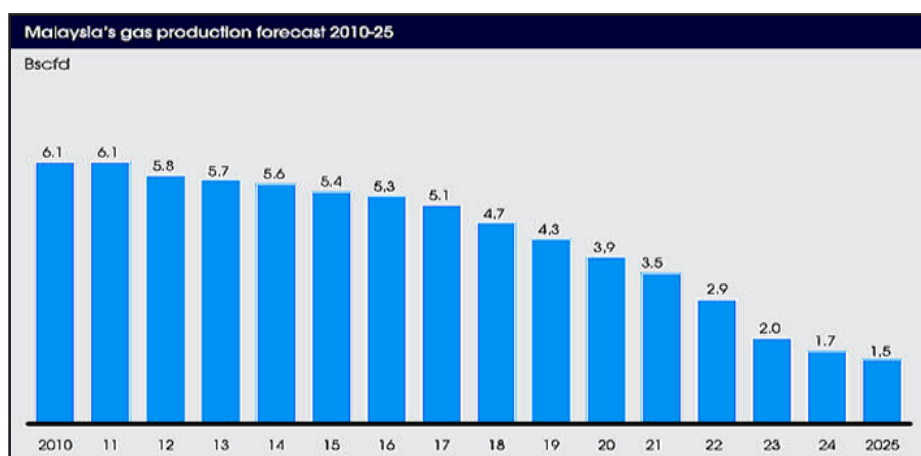


Figure 3.10.4: Natural gas production forecast for Malaysia (2010-2025)

Source: Economic Transformation Programme, 2010

There are 5 oil refineries with an aggregate capacity of 492 thousand barrel per day in Malaysia. The company-wise locations and capacity of the refineries are given in Table 3.10.1. Since 1998 oil refinery capacity is almost stagnant and refineries are already operating almost at full utilization level. Traditionally, Malaysia has been an exporter of crude oil and also a net exporter of petroleum products. However, if refinery capacity is not increased further, Malaysia will have to import petroleum products to meet its increasing domestic demand of petroleum products.

Table 3.10.1: Oil refinery capacity in Malaysia

Name of the company	Location	Start-up year	Capacity (thousand barrels/day)
SHELL Refining Co. (FOM) Bhd	Port Dickson, Negeri Sembilan	1963	155
ESSO Malaysia Bhd	Port Dickson, Negeri Sembilan	1960	88
PETRONAS	Kertih, Terengganu*	1983	49
PETRONAS	Melaka	1994	100
Malaysia Refining Company Sdn Bhd (PETRONAS/ConocoPhillips)	Melaka	1998	100
Total			492

Note (*): Excludes condensate splitter of 74,300 barrels per day
Source: NEB, 2010

3.10.2.2 Coal

The country's inferred coal reserves as on 31st December 2010, mainly in Sarawak and Sabah were estimated at 1,279 million tonnes. Total production of coal was 2.39 million tonnes in 2010 with the entire coal production from the Sarawak region. Of the total domestic coal production, coking coal accounted for only 5%, while 95% was non-coking coal. Table 3.10.2 presents the location-wise reserves and production of coal. World Energy Outlook 2009 reports that, Malaysia's coal production is expected to increase to 1.6 million tonnes in 2015 and 3 million tonnes in 2030 (IEA, 2009a).

Malaysia imports coal mainly from Indonesia and Australia. In 2010, around 13 Million tonnes of coal was imported. While the data in the Energy Balances does not disaggregate the imports by coking and non-coking coal, analysis indicates that 87% of the coal is consumed by power sector and 13% by industrial sector. Accordingly, it is expected that most of the imported coal is non-coking coal.

Table 3.10.2: Coal production and reserves as of 31st December 2010

Location	Reserves (million tonnes)			Production (metric tonnes)	Coal Type
	Measured	Indicated	Inferred		
Sarawak					
Abok & SilantekSri Aman	7.25	10.60	32.40	126,919	Coking coal, semi-anthracite, anthracite
Merit-Pila, Kapit	170.26	107.02	107.84	466,840	Sub-bituminous
Bintulu	6.00		14.00		Bitumen (partly Coking)
Mukah-Balingian	86.95	170.73	646.53	1,792,237	Lignite & sub-bituminous
Tutoh Area	5.58	34.66	162.33		Sub-bituminous
Subtotal	276.04	323.01	963.10	2,385,996	
Sabah					
Silimpopon	4.80	14.09	7.70		Sub-bituminous
Labuan			8.90		Sub-bituminous
Maliau			215.00		Bituminous
Malibau		17.90	25.00		
South West Malibau		23.23			
Pinangan, West Middle Block			42.60		Bituminous
Subtotal	4.80	55.22	299.20		
Selangor					
Batu Arang			17.00		Sub-bituminous
Subtotal			17.00		
Total	280.84	378.23	1279.30	2,385,996	

Source: NEB, 2010

3.10.3 Energy Prices

The economic costs of energy resources have been considered in the model. Accordingly, taxes and subsidies are not considered to reflect the price differentiation across various consuming segments/uses. As such, cost insurance and freight (c.i.f.) prices are considered for imported fuels while freight on board (f.o.b.) prices are taken for domestic extraction and exports. For fuel prices in the future, latest fuel prices projection by IEA as published in World Energy Outlook 2011 under the current policy scenario are used (Table 3.10.3). In view of regional variation in prices of imported natural gas, the price trajectory reported for export of natural gas to Japan is considered for analysis. For LNG import, an addition of re-gasification cost has been used to estimate net import cost. The freight on board prices for petroleum products are estimated by using average value of the ratios of their prices with respect to the crude oil price. The cost insurance and freight prices are estimated by adding load port charges, freight, insurance, and ocean losses to the freight on board prices.

Table 3.10.3: Fossil-fuel price projection¹⁰⁶

Fuel	Unit	2010	2015	2020	2025	2030
Crude Oil	USD/barrel	78.1	106.3	118.1	127.3	134.5
Natural Gas	USD/MMBtu	11.9	12.7	13.5	14.2	14.8
Coal	USD/tonne	99.2	104.6	109.0	112.8	115.9

Source: World Energy Outlook, 2011

3.10.4 Power Generation

3.10.4.1 Power Sector Overview

Access to affordable and reliable electricity is critical to a country's growth and prosperity. Malaysia has made significant progress towards the augmentation of its power infrastructure. In 1900, the Sempam Hydroelectric Power was set up as the first power station in Malaysia.

The major power producers in Malaysia consist of Tenaga Nasional Berhad (TNB), Sabah Electricity Sdn Bhd (SESB) and Sarawak Energy Berhad (SEB). Since the major electricity blackout crisis in Peninsular Malaysia in September 1992, Independent Power Producers (IPPs) have been introduced to compensate for the power outage in Malaysia. Due to the fast growing petroleum exploration industry in Malaysia, the government formulated the National Energy Policy in 1979 to ensure efficient, secure and environmentally sustainable supplies of energy. In order to ensure sustainability and reduce dependency on oil as the main energy resource, in 1981, government of Malaysia introduced the Four Fuel Diversification Policy which aimed to increase emphasis on natural gas, hydro and coal as part of the energy fuel mix in the country (Energy sector policies and programmes are described in detail in the Annexure). The natural gas has been a major resource for power generation in later years.

¹⁰⁶ Prices are given at 2010 constant price

Apart from natural gas, increased availability of hydro and coal is expected to help in diversifying the generation fuel mix and reducing the dependence on the fast depleting and market-driven petroleum fuels. This may ensure sustainability of fuel mix, and reliable electricity supply in the country.

Table 3.10.4 presents the electricity generation capacity over time in Malaysia, which shows that the installed electricity generation capacity has increased 1.8 times from 13,541 MW in 1997 to 24,356 MW in 2010 at an average annual rate of 5%. The share of gas based electricity generation capacity first rapidly increased from about 57% in 1997 to 74% in 1999, and then again decreased gradually to 57% again in 2010. The reduction is being compensated with the increase of coal generation from less than 4% in 1997 to more than 31% in 2010.

Table 3.10.4: Installed electricity generation capacity

Year	Installed Electricity Generation Capacity (MW)					Total
	Coal	Natural gas	Hydro	Oil	Other Renewables	
1997	600	7,767	2,025	3,148	0	13,541
1998	700	8,203	2,104	2,599	0	13,606
1999	664	9,440	2,092	540	0	12,737
2000	700	10,017	2,116	991	0	13,824
2001	1,700	10,046	2,119	949	0	14,813
2002	1,700	10,797	2,106	1,068	0	15,671
2003	3,800	13,712	2,115	492	0	20,119
2004	3,761	17,375	2,309	476	0	23,921
2005	3,880	14,778	2,091	1,575	0	22,324
2006	4,580	12,854	2,120	669	0	20,223
2007	5,980	13,066	2,120	649	0	21,815
2008	5,980	13,196	2,120	653	39	21,988
2009	7,650	13,911	2,113	662	41	24,377
2010	7,650	13,852	2,107	480	50	24,361

Source: NEB, 2010

While, natural gas still accounts for the largest share of electricity generation, share of coal is increasing rapidly. Further, coal based electricity generation is expected to increase with two coal power plants of 1,000 MW each coming up by 2015 and 2016. The first 1,000 MW coal-fired power plant is likely to commence at TNB Janamanjung in March 2015, and the second 1000 MW plant would be operational at Malakoff, Tanjung Bin in March 2016 ^{107,108}. In addition a Fast Track Project 3A, Ultra-Supercritical Coal Power Plant-1,000MW is anticipated to be commissioned in Oct 2017 and Project 3B, Ultra-Supercritical Coal Power Plant – 2x1,000MW is to be commissioned in October 2018 and April 2019 respectively.

The recent curtailment of natural gas supply by Petronas for power generation due to maintenance and upgrading has impacted energy supply in Malaysia. The contracted gas volume of 1,744 mmscfd is required for full operation of gas based power plants. However, current supply of gas is limited to 1,050 mmscfd and this is expected to increase to 1,350 mmscfd upon re-gasification terminal (TNB, 2012).

Table 3.10.5 presents the electricity generation by fuel type over time in Malaysia. Similar to the generation capacity, electricity generation in 2010 has increased more than 1.9 times from 57,872 GWh to 108,327 GWh at an average annual rate of 5% during the period 1997-2010.

Table 3.10.5: Electricity generation by fuel source (1997-2010)

Year	Electricity Generation (GWh)					Total
	Coal	Natural gas	Hydro	Oil	Other Renewables	
1997	3,063	36,547	3,872	14,390	0	57,872
1998	3,176	42,810	4,854	9,861	0	60,701
1999	4,628	48,142	7,523	4,928	0	65,221
2000	4,560	53,961	7,414	3,309	0	69,244
2001	7,691	53,230	6,435	4,062	1	71,419
2002	8,875	52,183	5,301	7,873	1	74,233
2003	11,262	58,480	5,750	2,972	1	78,465
2004	17,052	56,618	5,827	2,465	1	81,963
2005	19,989	57,166	5,186	2,484	1	84,826
2006	21,511	58,739	6,442	3,133	1	89,826
2007	27,006	61,797	6,488	2,222	1	97,514
2008	26,177	61,910	7,459	1,845	0	97,391
2009	32,495	63,812	6,671	2,103	0	105,081
2010	44,223	56,961	5,703	1,441	0	108,327

Source: NEB, 2010

¹⁰⁷ http://www.st.gov.my/index.php?option=com_content&view=article&id=5632%3Aenergy-commission-seeks-proposal-on-second-coal-fired-power-plant-from-two-operators&catid=794%3Aenergy-news&Itemid=1201&lang=en

¹⁰⁸ <http://www.mmc.com.my/content.asp?menuid=100041&rootid=100003&Mediald=581>

Table 3.10.6 shows the annual installed capacity, maximum demands and reserve margin in Peninsular Malaysia, Sabah and Sarawak from 2005 to 2010. While the maximum demand has been increasing every year, each of the 3 regions has been able to increase installed capacity as well to maintain a fair reserve margin.

Table 3.10.6: Reserve margin in Malaysia (2005 – 2010)

Year	Peninsular Malaysia			Sabah			Sarawak		
	Installed Capacity (MW) (a)	Max Demand (b)	Reserve Margin (%) (c) = (a-b)/bx100	Installed Capacity (MW) (a)	Max Demand (b)	Reserve Margin (%) (c) = (a-b)/bx100	Installed Capacity (MW) (a)	Max Demand (b)	Reserve Margin (%) (c) = (a-b)/bx100
2005	17,623	12,493	41.06	660	548	20.44	957	743	28.80
2006	18,323	12,990	41.05	708	594	19.19	967	773	25.10
2007	19,723	13,620	44.81	708	625	13.28	967	834	15.95
2008	19,723	14,007	40.81	812	673	20.65	1,102	860	28.14
2009	21,817	14,245	53.16	978	719	36.02	1,230	996	23.49
2010	21,817	15,072	44.75	1,111	760	46.18	1,347	1,091	23.46

Source: Energy Commission, 2012

The reserve margin ranges from 40.8% to 53.2%, for Peninsular Malaysia, from 13.3% to 46.2% in Sabah and from 16.0% to 28.8% in Sarawak. The reserve margin in Sabah has decreased to 14% in 2010, implying the need for increasing the generation capacity further. Sabah is particularly vulnerable to blackouts like the Peninsular Malaysia 1992 blackout, in case its installed capacity is not enhanced quickly. Due to the growing energy demand in Sabah, in August 2010, TNB, Petronas and Sabah have proposed a new 300 MW Gas Fired Combined Cycle Plant to be installed in Lahad Datu Palm Oil Industrial Cluster (POIC), East Coast of Sabah. The proposed Combined Cycle Plant at Lahad Datu POIC is based on the fact that additional capacity at the west coast transmitted through existing Sabah's grid will not solve the power shortage at the east coast. In addition to that, the cost of transporting power from Bakun Dam is very high and risky as the transmission line has to pass through at least 600km forest reserve and land ^{109,110,111}.

¹⁰⁹ Article on Proposed coal-fired plant in Lahad Datu to be further discussed [Available on 19.07.2011] from <http://www.nst.com.my/articles/Proposedcoal-firedplantinLahadDatutobefurtherdiscussed/Article/>

¹¹⁰ Article on Sabah Cancel Lahad Datu Power Plant [Available on 19.07.2011] from <http://www.themalaysianinsider.com/malaysia/article/sabah-cancels-lahad-datu-coal-power-plant/>

¹¹¹ News on TNB may need alternative power plant solutions for Lahad Datu [Available on 19.07.2011] from <http://biz.thestar.com.my/news/story.asp?file=/2010/8/21/business/6895675&sec=business>

In case of Sarawak's energy development, hydro is expected to be the major fuel contributing to more than 80% of the fuel mix by 2020 if the proposed 13 hydro power plants in Sarawak are built as planned.

3.10.4.2 Technology Assessment for Power Sector in Malaysia

The power generation technologies are broadly characterized as:

- i. Centralized power generation technologies, and
- ii. Decentralized power generation technologies

Centralized power generation technologies feed to the grid and are associated with investment in transmission and distribution infrastructure whenever new capacity is added. The energy generated from centralized power plants is subject to transmission and distribution losses. The centralized power-generation technologies include thermal based power generation technologies (including grid-based coal and gas technologies), hydro, solar grid-connected, biomass based and small hydro electricity generation technologies.

Decentralized power-generation technologies are not subject to transmission and distribution (T&D) losses as is the case in centralized power generation technologies. These include the captive industry plants based on coal, diesel, gas, wind, solar photovoltaic (with and without battery bank) and biomass based power plants.

Power generation technological types are further characterized under the following sub-session:

- i. Thermal Power Generation
- ii. Hydro Electricity
- iii. Nuclear Energy
- iv. Renewable Energy

Table 3.10.7: Technology wise breakdown of power plants by type in 2009 for TNB and IPPs

Technology	Share of Total Power Capacity in 2009 (%)		Share of Total Power Sector Generation in 2009 (%)		Average Efficiency in 2010 (%)	
	TNB	IPP	TNB	IPP	TNB	IPP
Conventional (oil/gas)	0.9	2.2	0.0	0.2	25.6	32.3
Conventional (coal)	0.0	25.9	0.0	27.1	N/A	33.1
Combined-cycle gas	12.5	21.2	20.3	24.0	41.2	41.9
Open cycle gas	4.9	4.1	0.3	4.3	22.6	27.3
Open cycle dist.	0.2	0.0	0.0	0.0	N/A	N/A
Hydro	6.9	0.0	5.0	0.0	N/A	N/A

Source: TERI Analysis 2012 adapted from Energy Commission, 2012

i Thermal Power Generation

Combined cycle gas power plants account for the highest share of electricity generation as well as for generation capacity, followed by coal. Open cycle power plants are used for meeting peak demand. In Malaysia conventional steam cycle with sub-critical steam parameters technology is currently being used for coal based thermal power generation. New gas turbine combined cycles for natural gas are employing E/F class technologies.

Clean coal technology refers to a collection of technologies developed to reduce the environment impact from coal energy generation. The technologies used will help in reducing carbon dioxide emissions and other pollutant emissions, such as sulphur oxides (SO_x), nitrogen oxides (NO_x), carbon monoxide (CO) and particulate matter from releasing into the atmospheric due to burning of coal.

Generally, clean coal technology can be divided into 3 major parts, namely, combustion system, gasification system and Carbon Capture and Storage (CCS).

At present, Malaysia's coal based generation is based on sub-critical technology only. The first step towards advanced coal generation technologies is expected to happen only by 2015, with the implementation of the Janamanjung plant which would be based on supercritical technology. Table 3.10.8 depicts the status of current clean coal technology development in Malaysia.

Table 3.10.8: Current status of clean coal technology in Malaysia

Description	Current Status in Malaysia
Combustion System Pulverized Coal Combustion (PVC) - Utilize steam as a working fluid in ranking cycle to transform the thermal energy from coal combustion to generated power - Two (2) important technical parameters in the improvement of steam cycle efficiency are the temperature and pressure of the steam cycle. The steam cycle efficiency can be divided as follows: i. Subcritical - Temperature :<580°C ; - Pressure: 21-23Mpa ii. Supercritical - Temperature: 538°C -580°C; - Pressure:23-28Mpa iii. Ultra-Supercritical - Temperature:580°C to above 600°C; - Pressure: Higher than 23Mpa Fluidized Bed Combustion (FBC) - Burning fuel in which the solid fuel particles are kept under certain appropriate condition that will cause the solid to behave like fluid. - This process helps to burn the coal more efficiently especially for low-grade coals and thus produces less NO_x and SO_x in comparison with the conventional Pulverized Combustion Process. - This technology can be further categorized into atmospheric (Circulating/Bubbling) and pressurized. The classification is made based on the operation of the units. - Units operate at atmospheric pressure are classified as bubbling-bed or circulating fluidized bed and also depends on the solid circulation.	- All the coal power plant boilers in Malaysia are subcritical power plant boiler which was implemented since 1980s. - The efficiency of those coal power plants are up to only 35% 1000MW supercritical coal power plant boiler will be implemented in an existing Janamanjung coal power plant by 2015 . - The existing Manjung power plant costs was USD1.1 million per MW and the estimated cost of extension is between RM5 million per MW (i.e., USD1.6 million per MW). The construction cost of Janamanjung power plant is more expensive compared to similar power plant built in China. - World's best PVC coal plant efficiency: - Subcritical up to 44% - Supercritical is up to 46% - Ultra-supercritical is up 48% to 49% - Use intended but has not been operational and implemented. - Study done by Universiti Putra Malaysia (UPM) on co-combustion of biomass with coal in fluidized bed combustor in 2008. - In Sweden, forest residues, sawdust, demolition wood and other waste wood, fibre and paper sludge are commonly used together with a smaller portion of coal or oil (15–30%) in district heating or combined heat power (CHP) plants using a variety of combustion technologies (grate-firing, BFBC, CFBC and pulverised combustion (PC).

table continues...

¹¹² http://climatetechwiki.org/technology/sup_crit_coal

¹¹³ <http://biz.thestar.com.my/news/story.asp?sec=health&file=/2011/4/8/business/8439956>

Description	Current Status in Malaysia
Gasification System	• In the gasification process, coal, steam and either air or pure oxygen react at an elevated temperature and pressure to produce synthesis gas (consist of CO₂, H₂ and impurities). • When a gasifier is incorporated into a combined cycle unit (a gas turbine/generator and a steam turbine/generator) the plant is referred to as (IGCC) plant. • The pulverized coal and oxygen are fed into a gasifier, which transforms the inputs into syngas. The hot syngas then passes through a heat exchanger to cool the gas and recover the heat. The cooled gas passes through a gas-cleaning unit prior to it being expanded in the gas turbine to produce electrical power. The turbine exhaust then passes through a heat recovery steam generator (HRSG) to recover the waste heat and use it to produce additional electricity. Typically, the gas turbine produces 65% of the power and the steam turbine 35%. • Open Cycle & Combine Cycle gas power plant has started since 1980s. • Average efficiency of gas power plant in Malaysia is¹¹⁴ - open cycle is 25.6 % - combine cycle is 41% • World's best Combined Cycle power plant efficiency up to 58%-60 %. • IGCC implementation in the world. • Edwardsport Indiana, USA with capacity 630MWe, USD2.9 billion, 2012. • Tianjin, China with capacity 250MW, USD 844 Million, 2011¹¹⁵. • RWE Goldenbergwerk, Germany with capacity 450MW, €2 billion (USD2.577 billion), 2015.

table continues...

¹¹⁴ TNB Annual Report 2009

¹¹⁵ <http://www.chinafaqs.org/blog-posts/updates-tianjin-progress-greengen-igcc-project>

Description	Current Status in Malaysia
Carbon Capture and Storage (CCS) System • This technology can be used in either combustion or gasification. • For combustion, post-combustion capture seems to be most appropriate. CO₂ would be removed by scrubbing with solvent such as amine solution • For gasification, pre-combustion capture seems to be more appropriate. CO₂ produced by syn-gas would be effectively removed by de-carbonized through water-gas shift conversion thus left with H₂ as a fuel for downstream application and CO₂ will be captured for storage or other purposes • Oxy-fuel combustion burns the coal in pure oxygen instead of air as the primary oxidant, producing only carbon dioxide (CO₂) and water vapour (H₂O), which are relatively easily separated. Since the nitrogen component of air is not heated, fuel consumption is reduced, and higher flame temperatures can be achieved. • Several other technologies available are: - Flue Gas Desulphurization (FGD) – to limit SO_x emissions - Electrostatic Precipitators (ESP) – to remove dust - Low NO_x Burner - Dust Suppression for coal yard	• Malaysia has become a member of Global CCS Institute since 2009 ¹¹⁶ • A 6-month period of Scoping Study on Carbon Dioxide Capture and Storage (CCS) in Malaysia has been carried out by MEGTW and Global CCS Institute involving various industry stakeholders. • Malaysia is exploring the CCS technology option to mitigate carbon footprint beyond 2030 as currently it is not commercially viable yet. • CCS, FGD & ESP are used in Jimah Power plant. Cost of power plant is USD 1.74bil. • FGD & Low NO_x Burner are also used in SJ Janamanjung. • Dust Suppression for coal yard is used in TNB Power Plant. • Dry Low NO_x Burner used in SJ GB3 Lumut Perak.

ii Hydro Electricity

Malaysia has abundant hydropower potential with a total potential capacity of 29,000 MW. About 70% of this lies in Sarawak, attributed to its abundant rainfall and topography characterized by numerous rivers flowing between steep, narrow, interconnected ridges of up to 1,200 metres high. The hydro potential sites which are concentrated in the interior of Sarawak in 11 river basins constitute the major portion of the unexploited hydropower resources in Malaysia. The current contribution of hydro power in Sarawak's generation fuel comes from the existing Batang Ai Dam (100 MW) and Bakun dam (2,400 MW). It is expected that by 2013, Muram (900 MW) dam located in the upper Rejang River Basin in central Sarawak will be starting operations. Government has proposed for power from Sarawak to be transmitted to Peninsula in post 2020.

¹¹⁶ <http://www.globalccsinstitute.com/institute/media-centre/media-releases/carbon-capture-and-storage-malaysia>

iii Nuclear Energy

Nuclear power planning studies has been taken up in Malaysia since 1979 by Malaysia Nuclear Agency. Nuclear Power has been identified and emphasised under the Tenth Malaysia Plan to increase capacity and diversify the generation fuel mix. Nuclear energy will be considered as a long-term option beyond 2020 in Peninsular Malaysia and not in Sabah and Sarawak due to its small grid system. Considerations such as detailed feasibility study, training of human capital and awareness campaigns, as well as radioactive disposal need to be thoroughly looked into when considering nuclear energy deployment in the country.

In formulating National Energy Master Plan the first nuclear power plant is proposed to be set up in Malaysia by 2025. On the technical aspects, further assistance from International Atomic Energy Agency (IAEA) will be required and needed as there are no trained competent nuclear engineers in the country to handle the technology especially on the radioactive nuclear material and waste. However, several nuclear programmes focusing on capacity building have been carried out in Malaysia with the help of IAEA experts. Those programmes are as follow:

- MAL3009: Building Capacity for Integrated National & Radioactive Waste Management Programme
- MAL4009: Building Capacities in Nuclear Power Programme Planning
- MAL4010: Capability Building in Planning for High Power Reactor & Its Application

Engaging public opinion on implementation of nuclear energy in the country is still yet to be carried out. In Malaysia, an existing nuclear programme called Public Information Nuclear Energy (PINE) has been introduced in 2009. This programme has set a target to achieve at least 70% public understanding and awareness by 2012¹¹⁷. This campaign is to help to reduce negative public perceptions and scepticism regarding the safety of nuclear energy.

iv Renewable Energy (RE)

Malaysia's renewable energy policy and programmes are in existence for more than 30 years. Five Fuel Diversification Policy introduced in 2001 has identified and recognized the potential of renewable energy for electricity generation from sources such as biomass, biogas, solar, mini-hydro and Municipal Solid Waste (MSW). This policy was emphasized under 8th Malaysia Plan (2001-2005) for developing RE generation for grid-connected electricity which was initially targeted at 600 MW or 5% of the fuel mix by 2005. In the Malaysia Plan (2006-2010), the target was reduced to 300 MW grid-connected capacity in Peninsular Malaysia and 50 MW in Sabah. Small Renewable Energy Programme (SREP) was introduced in 2001 to encourage production of RE from small power generators and allow them to sell their electricity back to national grid through RE Power Purchase Agreement (PPA).

¹¹⁷ Update on Nuclear Energy Programme in Malaysia by Mazleha Maskin (Malaysia Nuclear Agency), July 4-8, 2011 [Available on 4.8.2011] retrieved from http://www.iaea.or.at/NuclearPower/Downloads/Technology/meetings/2011-Jul-4-8-ANRT-WS/7_MALAYSIA_NuclearEnergyProgramme_Mazleha.pdf

The share of renewable is still negligible in Malaysia. Renewable accounted for around 0.49% of total installed capacity, and only 0.31% of total generation in 2010. Technology wise details of renewable based power projects in Malaysia by public and private are given in Table 3.10.9. and Table 3.10.10 respectively.

Table 3.10.9: Electricity generation and installed capacity of renewable energy by public licensee in 2010

Region	Energy Sources or Types of Fuel	Installed Capacity (MW)(%)	Units Generated (MWh)(%)
Peninsular Malaysia	Land Fill Gas	2.0 (4.08%)	949 (1.73%)
	Mini Hydro-ST	6.4 (13.06%)	33,195 (60.37%)
	Mini Hydro-TNB	8.9 (18.16%)	14,056 (25.56%)
	Solar	0.8 (1.63%)	666 (1.21%)
	POME	2.0 (4.08%)	1,436 (2.61%)
	Municipal Waste-ST	8.9 (18.16%)	4,587 (8.34%)
	Mini Hydro-IPP	20.0 (40.82%)	101 (0.18%)
	Sub-Total	49.0 (100.00%)	54,990 (100.00%)
Sabah	Palm Shell & EFB	10.2 (15.18%)	32,983 (12.09%)
	Wood Waste	10.0 (14.88%)	306 (0.11%)
	Mini Hydro-ST	2.0 (2.98%)	2,100 (0.77%)
	Palm Oil Waste	37.0 (55.06%)	214,359 (78.56%)
	Mini Hydro-SESB	8.0 (11.90%)	23,104 (8.47%)
	Sub-Total	67.2 (100.00%)	272,852 (100.00%)
Sarawak	Mini Hydro-SEB	2.0 (100.00%)	6,374 (99.77%)
	Solar	Negligible	15 (0.23%)
	Sub-Total	2.0 (100.00%)	6,389 (100.00%)
Grand Total		118.2	334,230

Source: NEB, 2010

Table 3.10.10: Electricity generation and installed capacity of renewable energy by private licensee in 2010

Region	Energy Sources or Types of Fuel	Installed Capacity (MW)(%)	Units Generated (MWh)(%)
Peninsular Malaysia	Agricultural Waste	90.0 (20.56%)	55,269 (10.83%)
	Wood Dust	12.5 (2.86%)	548 (0.11%)
	Paddy Husk	0.5 (0.11%)	2,189 (0.43%)
	Palm Oil Waste	318.8 (72.84%)	451,766 (88.53%)
	Others	15.9 (3.63%)	508 (0.10%)
	Sub-Total	437.7 (100%)	510,280 (100%)
Sabah	Palm Oil Waste	115.2 (59.60%)	221,649 (40.89%)
	Wood Waste	64.1(33.16%)	289,698 (53.44%)
	EFB/Palm Shell	7.5 (3.88%)	19,640 (3.62%)
	Agricultural Waste	6.5 (3.36%)	11,103 (2.05%)
	Sub-Total	193.3 (100%)	542,090 (100%)
Sarawak	Palm Oil Waste	7.4 (30.33%)	10,129 (21.44%)
	Wood/Sawmill Dust	11.1 (45.49%)	26,309 (55.68%)
	Mini-Hydro-SEB	5.9 (24.18%)	10,816 (22.89%)
	Sub-Total	24.4 (100%)	47,254 (100%)
Grand Total		655.4	1,099,624

Source: NEB, 2010

Table 3.10.11 shows the RE maximum potential in Malaysia as determined by SEDA. The study indicates that the maximum potential of RE from biomass, biogas and mini hydro that can be harvested are limited at 1340MW, 410MW and 490MW respectively. Solar PV shows great potential with unlimited sunlight available during the day.

Table 3.10.11: Maximum RE potential and feed-in-tariff (FiT) in Malaysia

Renewable Energy Sources	Maximum Potential (MW)	Range of FiT Rates (RM/kwh)	RE Target 2015 (MW)	RE Target 2020 (MW)	RE Target 2030 (MW)
Biomass	1,340	0.24-0.35	330	800	1,340
Biogas	410	0.28-0.35	100	240	410
Mini Hydro	490	0.23-0.24	290	490	490
Solar Photovoltaic (PV)	Unlimited	1.25-1.75	65	190	1,370
Municipal Solid Waste (MSW)	430	0.30-0.46	200	360	390
Total			985	2,080	4,000

Source: SEDTA, 2012

Biomass is one of the most important potential sources of renewable energy in Malaysia. Resources are available from palm oil plantations, forestry and wood industry, rice husk and several other agricultural sources and agro-industries. Presently the largest fraction of solid biomass fuels is used (ineffectively) as a boiler fuel in palm oil industry, but also to some extent in wood industries, rice mills, sugar mills etc. The available resources are already in use, either as an industrial raw material, for food/feed purposes or for energy.

Virtually, all of the present utilization of solid biomass fuels takes place in industries, that have direct access to the biomass, and which are used to handling large volumes of the products. Outside the biomass handling industries a market for biomass fuels is non-existent with the exception of a few cement industries and rubber glove industries.

It has been identified that RE from biomass for the off-grid is estimated to be able to produce around 430MW from the existing private palm oil millers. However, one of the challenges is the infrastructure to connect the biomass plant to the national grid. Malaysia RE Act has been passed by Parliament in April 2011 which emphasized on pricing policies where utilities is obligated to purchase RE from eligible developer. This policy is implemented under 10th Malaysia Plan (2011-2015) and beyond. RE from wind and Ocean Thermal Energy Conversion (OTEC) are currently not part of Malaysia RE Policy and Action Plan, however, several studies have been conducted to determine the potential of these technologies in the country.

As per National Renewable Energy Policy and Action Plan, it has been envisaged the RE sector to be accelerated to grow at compounded annual growth rate (CAGR) of 18% from 2010 to 2030. A target of 2,080MW cumulative RE is set to be achieved by 2020 which would account for 11% of the total maximum demand. This will help to enhance the utilisation of indigenous renewable energy resources to contribute towards national electricity supply security and sustainable socio-economic development. The latest annual RE capacity target (MW/year) till 2050 is shown in Figure 3.10.5.

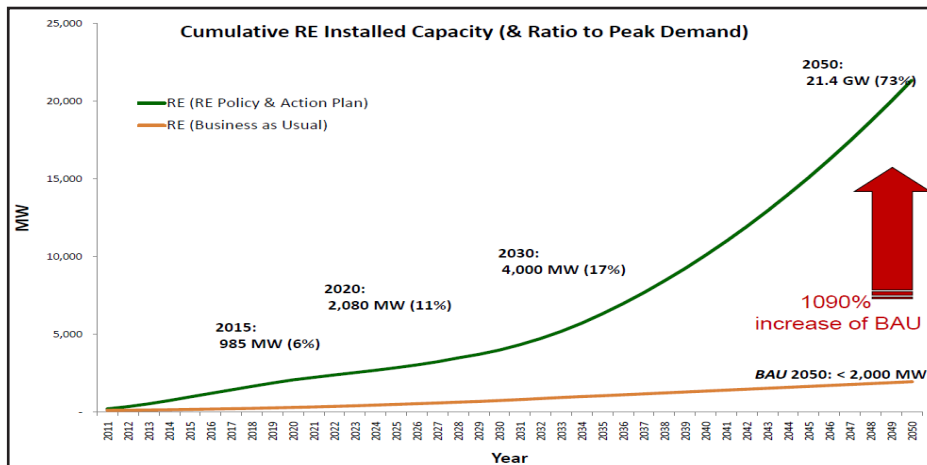


Figure 3.10.5: Renewable energy policy and action plan target

Source: SEDA, 2012¹¹⁸

Currently, the renewable energy sources are financed through a contribution of one percent of the retail electricity. The RE revenues collected will go into a fund which will finance the tariff payment for renewable electricity producers under the national feed-in tariff. In order to increase the share of renewable electricity in the future, the government would have to further increase the electricity tariff (i.e., two to five percent of electricity tariff).

Other source of financing the feed-in tariff fund is by introducing the tax on the electricity produced from conventional power generation. This would help to generate incomes for the FIT fund. In fact, the current power generation costs of natural gas and coal in Malaysia do not reflect the real costs for the society, since the negative external costs (e.g. CO₂ emission) are not being internalized. The negative external costs can be internalized via an electricity tax. At the same time, the money from taxing conventionally produced electricity can be channelled to support the cleaner renewable energy sources¹¹⁹.

¹¹⁸ Presentation made by SEDA on The Renewable Energy Roadmap in National Energy Security 2012 Conference

¹¹⁹ "Assessment of the proposed Malaysian feed-in tariff in comparison with international best practise" by Dr. Des. David Jacobs, November 30, 2010 (Available on 24.10.2012) retrieved from http://www.mbipv.net.my/dload/Jacobs+FIT_for_Malaysia+final.pdf

Another option is to have a certain share of the revenues made from the exporting of fossil fuels to support the nationally available renewable energy sources. By having a small fraction of the incomes generated from exporting fossil fuels (i.e., natural gas and oil) for the FIT fund, Malaysia could significantly increase its targets for renewable energy deployment. At the same time, Malaysia would use less fossil fuel for electricity generation in the country and will have more resources available for fossil fuels exporting¹²⁰.

In order to further promote green technology, the government of Malaysia has taken the initiative by introducing The Green Technology Financing Scheme (GTFS) fund. The fund was launched in early January 2010 with the intention to attract private sector to participate in Green Technology entrepreneurship. A total amount of RM 1.5 billion is allocated by Malaysian government to provide soft loan to green technology producers (maximum RM 50 million) and green technology user (maximum RM 10 million). Government will bear 2% of the total interest as a subsidy (MEGTW, 2010). In addition to that, government will also provide a guarantee of 60% on the financing amount via Credit Guarantee Corporation Malaysia Berhad (CGC), with the remaining 40% financing risk to be borne by participating financial institutions. This scheme is expected to benefit 140 companies by the end of 2012¹²¹. To date, approximately RM 800 million has been approved to 50 local companies. The fund for GTFS will be increased by RM 2 billion to further boost the production and utilisation of green technology-based products, and the application period be extended for another three years ending on 31 December 2015¹²².

3.10.4.3 GHG Emissions Overview of Power Sector

The main source of emissions from the power sector is combustion of fossil fuels in the power plants. Since thermal power generation accounts for more than 90% of the total electricity generated in Malaysia, the emissions are primarily due to the combustion of fossil fuels (natural gas, coal, and diesel). In national inventory power sector is covered under GHGs emission inventory for energy prepared for 2000 to 2007.

¹²⁰ Ibid. 119, p. 188

¹²¹ "1PROGRESS Roundtable Seminar", July 4 2011 (Available on 11.08.2011) retrieved from <http://www.kettha.gov.my/en/content/1progress-roundtable-seminar%E2%80%99>

¹²² "The 2013 Budget Speech", September 28 2012 (Available on 24.10.2012) retrieved from <http://www.nst.com.my/2013budget/full-text-of-the-2013-budget-speech-1.149226>

Table 3.10.12: Trend of CO₂ eq. emissions from fuel combustion and electricity generation

Year	Emissions from fuel combustion activities ('000 tonnes)	Emissions from electricity generation ('000 tonnes)
2000	125,005	37,958
2001	131,604	41,524
2002	138,333	47,007
2003	148,095	44,564
2004	162,735	49,271
2005	177,182	57,452
2006	175,660	61,019
2007	189,604	66,860

Source: GHG Inventory for Energy Sector and Industrial Processes for NC2, 2009 by PTM

As indicated in Table 3.10.12, CO₂ eq. emissions from electricity sectors increased from 37.96 million tonnes in 2000 to 66.86 million tonnes in 2007, growing at a rate of 8.4% per annum. Given that Malaysia's power sector is largely based on fossil fuels, the annual growth rate in CO₂ eq. emissions from electricity sector is higher than the growth rate of total GHG emissions (5.7% per annum) in the country and also higher than growth rate of CO₂ eq. emission from fuel combustion activities. Moreover, the growth rate in CO₂ eq. emissions from electricity sector is higher than the growth rate of electricity generation, which implies that CO₂ eq. emissions per unit of electricity generation for Malaysia is increasing. The emission factor for Malaysia electricity generation by regions for base year 2009 were 0.683 tCO₂/MWh, 0.805 tCO₂/MWh and 0.612 tCO₂/MWh for Peninsular Malaysia, Sarawak and Sabah respectively¹²³. The increase of CO₂ eq. emission of electricity generation could be attributed to the increased share of coal in electricity generation (Table 3.10.3).

¹²³ "Study on Grid Connected Electricity Baselines in Malaysia Year: 2009 – Final Report", GreenTech Malaysia, January 2011 (Available on 24.10.2012) retrieved from http://cdm.greentechmalaysia.my/up_dir/CDM%20Electricity%20Baseline%202009.pdf

3.10.5 Future Scenarios for Power Sector

In power sector two scenarios viz. Business-as-Usual (BAU) scenario and ambitious (AMB) scenario have been developed. The BAU scenario is characterized by most-likely path of development in absence of any major interventions. However, this scenario incorporates existing government plans and policies to the extent of their likely implementation. With regards to technology penetration in the power sector, limited deployment of efficient technologies for coal and gas based power generation are assumed. The penetration of various renewable energy technologies is considered as per existing trend and expert opinion.

In AMB scenario, taking the assumption that Malaysia would leapfrog to world best technology, it means that all new coal based plants will be of supercritical technology with 46% efficiency (IEA, 2008) as compared to 40% efficiency in the BAU scenario. Similarly all new combined cycle gas based plants will be of H-frame technology with 60% generation efficiency in the ambitious scenario, while BAU scenario assumes deployment of combined cycle power plants with 55% of efficiency.

In the ambitious scenario deployment of renewable energy is assumed as per renewable energy policy and action plan target (Figure 3.10.5) while in BAU, there is limited penetration of renewable energy. The ambitious scenario also considers a higher use of gas in power generation as gas lowers carbon emissions. Nuclear is only considered in the AMB scenario and comes in after 2025.

In both scenarios, electricity demand is derived from the bottom up analysis, and subsequently in the integrated modelling exercise, power generation fuels as well as technologies are selected based on overall optimization of the entire energy sector.

3.11 MARKAL Analysis and Results

This study has used the MARKAL modelling framework for conducting an integrated analysis for the energy sector. The energy demand projections, supply trajectories, technical data and assumptions described in the earlier chapters are incorporated into the model database and the BAU and ambitious scenarios have been further assessed using this model.

MARKAL is a dynamic linear-programming (LP) model of a generalized energy system. The model uses linear programming methods to solve for the fuel and technology mix that minimises the overall system costs. It is demand-driven for which feasible solutions are obtained only if all specified end-use demands for energy are satisfied for every time period. The end-use energy demand for each demand sector and each time period are exogenously projected and provided as inputs to the model.

The MARKAL model optimizes overall energy system costs under a set of linear constraints. The problem is to determine the optimum activity levels of processes that satisfy the constraints at a minimum cost. Examples of constraints in the model include availability of primary energy resources, production/use balances, electricity/heat peaking, availability of certain technologies, and upper bounds on pollution emissions.

The elements of MARKAL simulate the flow of energy in various forms (energy carriers) from the sources of supply (import, export, mining, and stockpiling) through transformation systems (resource, process, conversion, and demand technologies) to the demand devices which satisfy the end-use demands.

The MARKAL model structure is shown in Figure 3.11.1

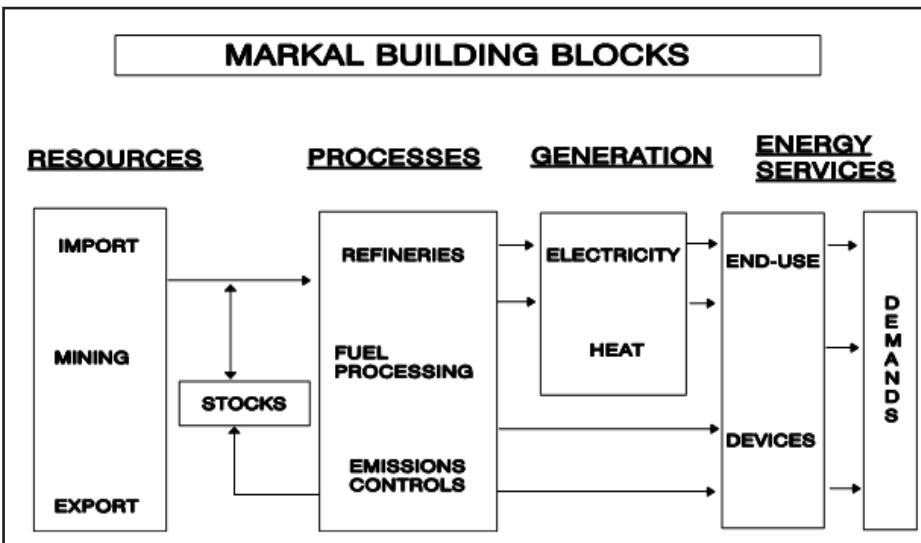


Figure 3.11.1: MARKAL building blocks

This section presents the findings for the Business-as-Usual and an ambitious scenario modelled within the MARKAL framework using assumptions and inputs for energy supply, sectoral demands and technology progression as detailed in the preceding sections 3.7 to 3.10. The “ambitious scenario” presented in this section brings together the most ambitious alternative scenarios considered within each of the individual sector section in the report.

3.11.1 Results and Analysis of Business-As-Usual Scenario and the Ambitious Scenario

3.11.1.1 Business-As-Usual Scenario

3.11.1.1.1 Primary Energy Supply in the Business-As-Usual Scenario

(a) Total Primary Energy Supply

The total energy use in the Malaysian economy increases from 65,419 ktoe in 2010 to 119,437 ktoe in 2030 under the BAU scenario as indicated in Figure 3.11.2. Oil accounts for the largest share of fuels over the entire modelling period.

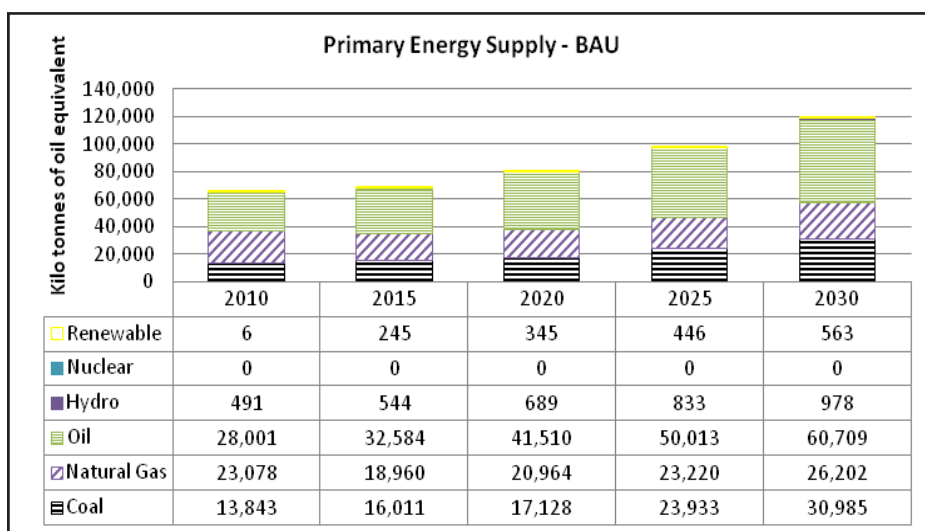


Figure 3.11.2: Primary energy supply in BAU scenario

Source: TERI analysis, 2012

The share of coal in primary energy supply increases and is seen to substitute natural gas mostly due to the increasing use of coal in the power generation sector. The use of coal has increased since the adoption of the Four Fuel Diversification Policy and the model indicates the preference for coal by virtue of it being the cheapest fossil fuel option especially for power generation.

(b) Imports and Import Dependency

The energy imports increase in Malaysia over time in the BAU scenario as reflected in Figure 3.11.3.

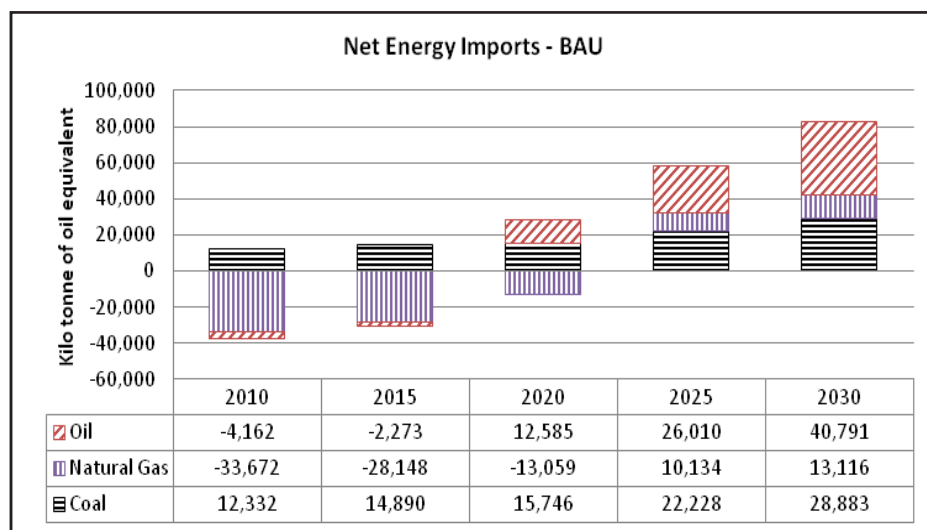


Figure 3.11.3: Net import of energy in Malaysia in BAU scenario

Source: TERI Analysis, 2012

While the country is a net exporter of energy resources at present and in short term it is importing coal, in the future, the model indicates increasing imports of oil and natural gas as well Malaysia may consequently become a net importer of energy and energy import dependency of Malaysia could increase to 70% by 2030 as reflected by the model.

(c) Electricity Generation

The contribution of different fuels in power generation is given in Figure 3.11.4 and fuel wise power generation capacity is given in Figure 3.11.5. Power generation is observed to shift from natural gas to coal over the years, due to coal being cheaper and also on account of Malaysia's 'four fuel diversification' policy.

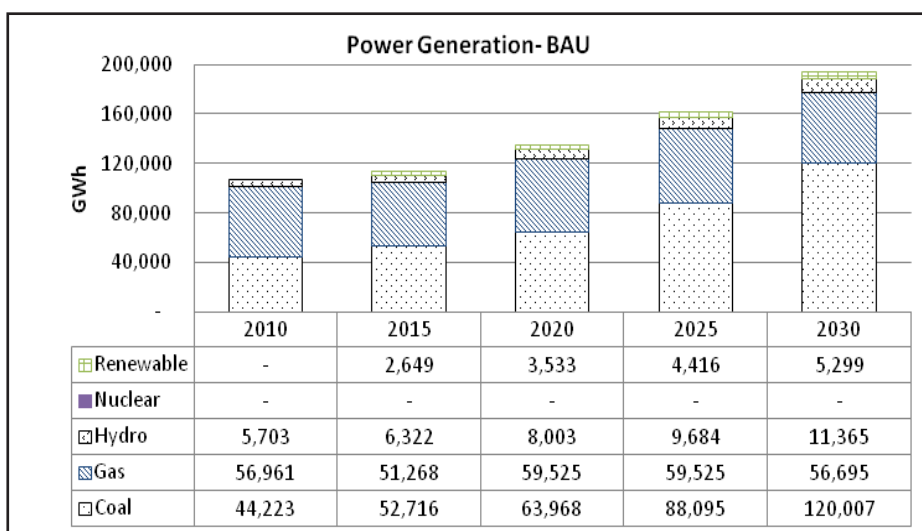


Figure 3.11.4: Power generation – BAU scenario

Source: TERI Analysis, 2012

The contribution of coal in power generation increases from 41% in 2010 to 62% in 2030, while that of natural gas drops from 53% to 29% during same period. Share of renewable in power generation increases from negligible in 2010 to 3% in 2030, while in capacity terms renewables contribute to 9% by 2030.

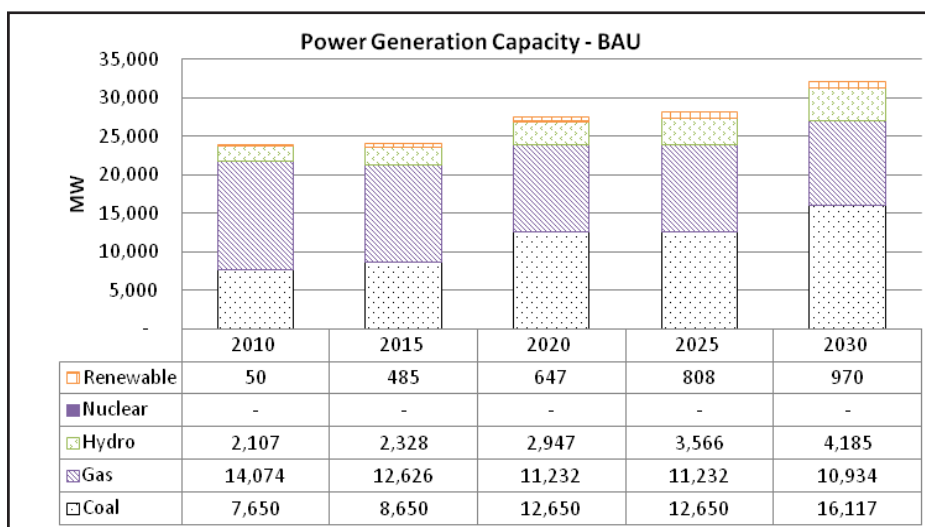


Figure 3.11.5: Power generation capacity – BAU scenario

Source: TERI Analysis, 2012

3.11.1.1.2 Final Energy Consumption in the Business-As-Usual Scenario

Figure 3.11.6 shows the total energy consumption in the Business-As-Usual scenario, from the end use consumption side sectors i.e. in terms of final energy use.

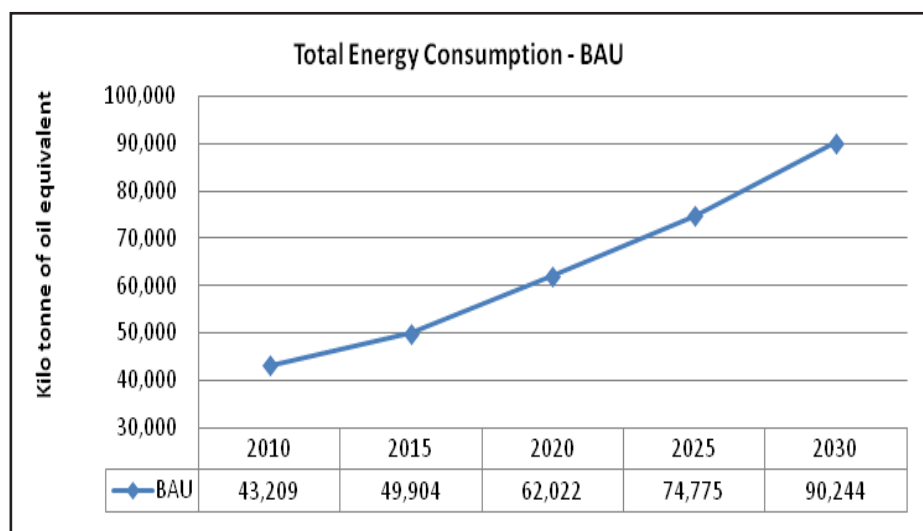


Figure 3.11.6: Final energy consumption for all end use sectors – BAU scenario

Source: TERI Analysis, 2012

The total energy consumption as reflected by the model increases from nearly 43,209 ktoe in 2010 to nearly 90,244 ktoe in 2030 showing an increase of 2.1 times over a period of 20 years.

The following sections examine the end use fuel consumption across different sectors.

i. Transport Sector

The fuel consumption in the transport sector in the Business-As-Usual Scenarios is shown in Figure 3.11.7.

The total fuel consumption in the transport sector increases from 20,420 ktoe in 2010 to 42,569 ktoe in 2030, at a compounded annual growth rate of nearly 3.7% in the Business-As-Usual Scenario. Gasoline has the highest share in the transport sector (58%) followed by diesel (30%) and ATF (12%) in 2010. Natural gas, electricity and fuel oil have marginal shares. In 2030, while share of gasoline in total fuel consumption in the transport sector increases to 59% and the share of diesel declines to 25%, mainly due to the high share of personalised vehicles. In absolute terms however, the use of diesel and biodiesel increased from 6,070 ktoe in 2010 to 10,702 ktoe in 2030.

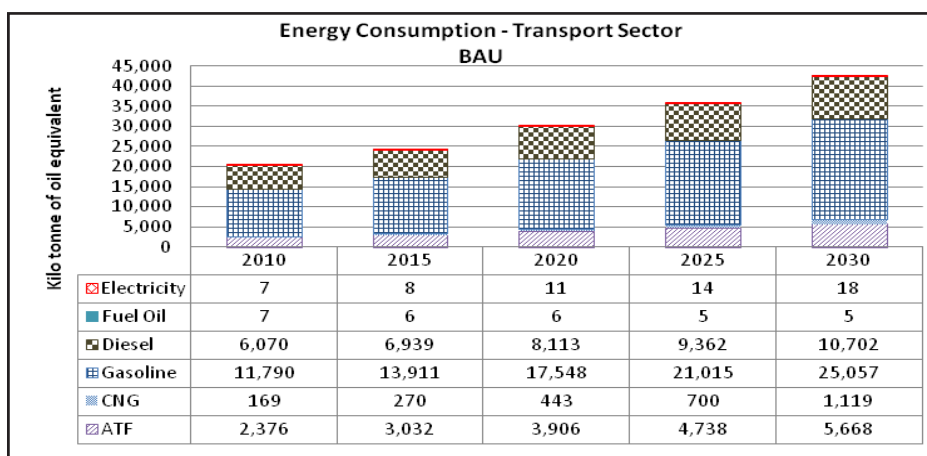


Figure 3.11.7: Energy consumption in transport Sector – BAU scenario
Source: TERI Analysis, 2012

ii. Residential Sector

Electricity meets most of the energy demand in the residential sector and accounts for 72% of the total consumption in 2010. LPG forms 28% of the energy requirement in 2010 and is used in cooking. Natural gas makes slight contributions to the energy demand. The total energy consumption in the residential sector increases from 2,481 ktOE in 2010 to 3,891 ktOE in 2030 (Figure 3.11.8) in the BAU scenario.

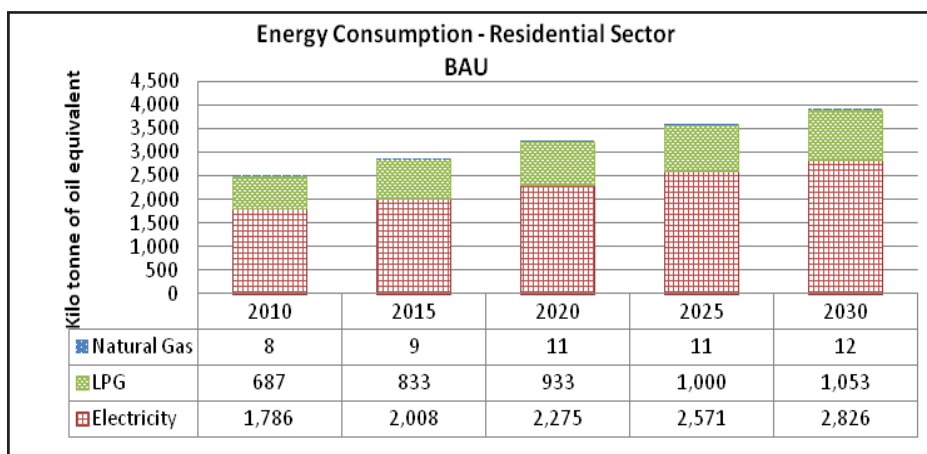


Figure 3.11.8: Energy consumption in residential sector – BAU scenario
Source: TERI Analysis, 2012

iii. Commercial Sector

Similar to the residential sector, primarily the commercial sector also uses electricity constituting 71% of the total energy consumption in 2010. The total energy usage increases from 3,918 ktoe in 2010 to 10,674 ktoe in 2030 in the commercial sector (Figure 3.11.9) in the Business-as-Usual scenario. The use of LPG fuel oil and natural gas also increases significantly over time, mainly on account of increase in the hospitality business.

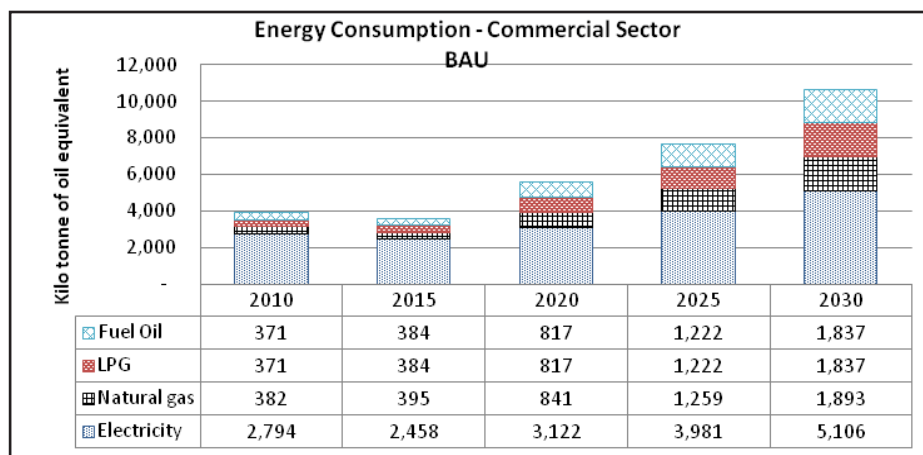


Figure 3.11.9: Energy consumption in commercial sector – BAU scenario

Source: TERI Analysis, 2012

iv. Industrial Sector

Figure 3.11.10 shows the total energy consumption in the industrial sector in the Business-as-Usual scenario. The total energy consumption in the industrial sector increases from 12,596 ktoe in 2010 to 24,368 ktoe in 2030, at a compounded annual growth rate of 3.4%. In the total energy mix, electricity has the highest share of 32% and the share of natural gas is 31% in 2010. In 2030, the share of natural gas remains at 31% but the share of electricity decreases to 31% in the BAU scenario due to energy efficiency improvements in the industrial sector.

3.11.1.1.3 CO₂ Emissions in the Business-As-usual Scenario

The CO₂ emission factors considered in the model for calculating the emissions are given in Table 3.11.1.

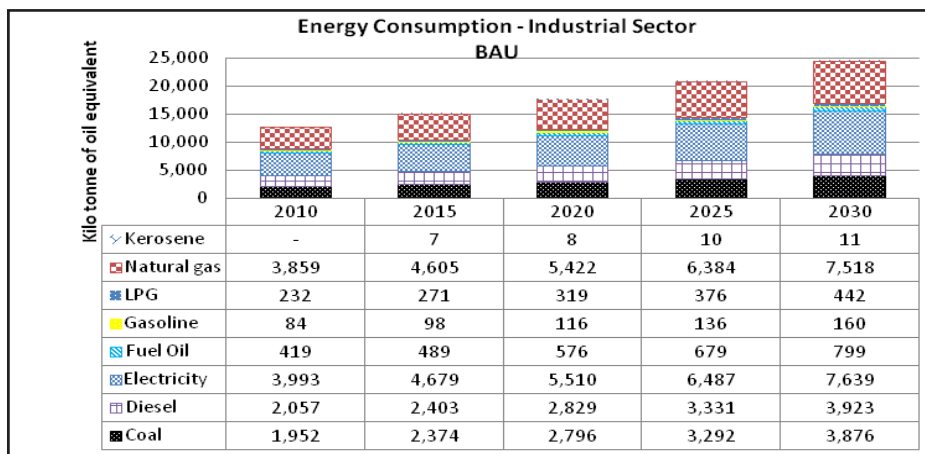


Figure 3.11.10: Energy consumption in industrial sector – BAU scenario

Source: TERI Analysis, 2012

Table 3.11.1: CO₂ emission factor

Type of Fuel	Emission Factor ('000 tonnes of CO ₂ per ktOE)
Fuel Oil	3.1959
LPG	2.6507
Natural Gas	2.3378
Non-Coking Coal	3.9662
Diesel	3.0589
Gasoline	2.9220
Refinery Gas	2.3990
Kerosene	2.9981
Non energy-Petroleum Products - Non Energy	3.0437
ATF	2.9981

Source: IPCC, 2006

Based on these factors, the emissions from various sectors in the Business-As-Usual scenario are provided in Figure 3.11.11.

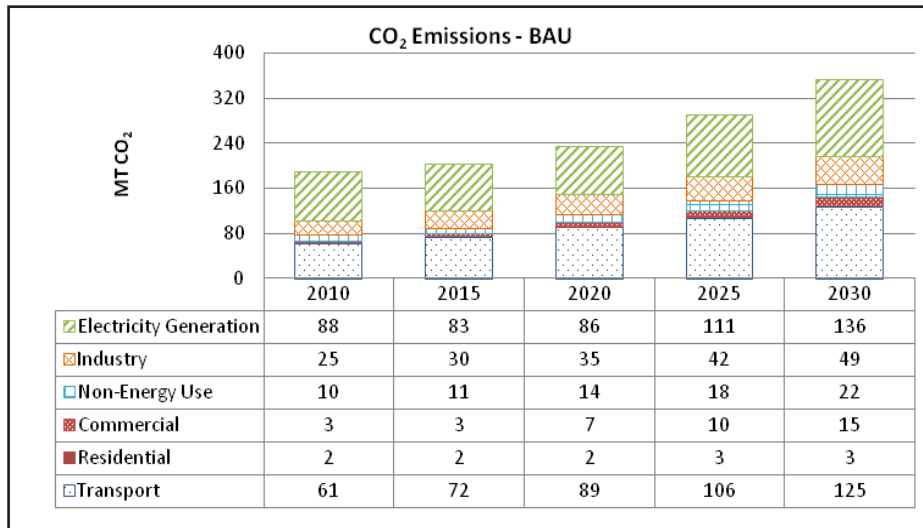


Figure 3.11.11: CO₂ emissions – BAU scenario

Source: TERI Analysis, 2012

The transport sector has the highest share in the emissions closely followed by electricity generation and then industrial sector. The emissions from electricity generation increase from 88 MtCO₂ eq. in 2010 to 136 MtCO₂ eq. in 2030. The emissions from the transport sector increase from 61 MtCO₂ eq. in 2005 to 125 MtCO₂ eq. in 2030, at a compounded annual growth rate of 3.7%.

Figure 3.11.12 shows the fuel wise emissions in the BAU scenario indicating that coal, gasoline, natural gas and diesel are key fuels expected to contribute to the increasing emission in the BAU scenario.

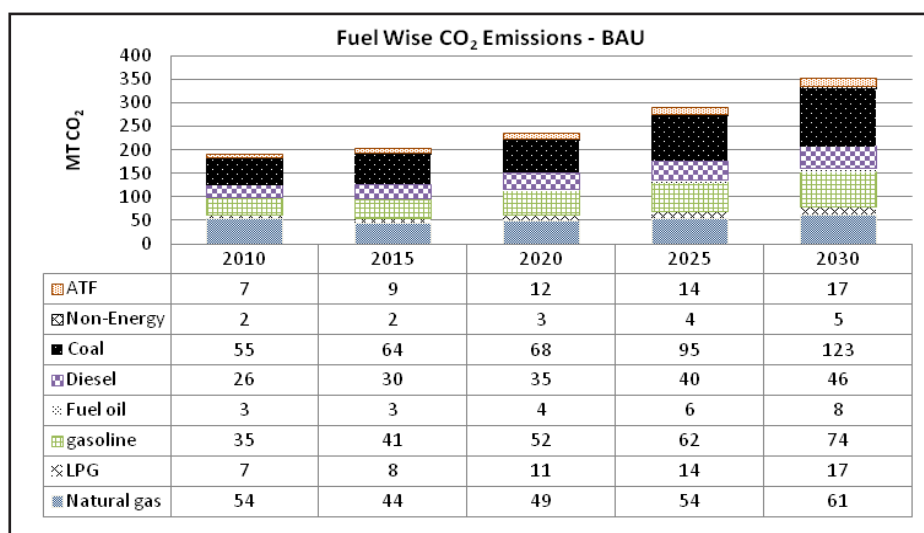


Figure 3.11.12: Fuel wise CO₂ emissions for energy sector in BAU scenario

Source: TERI Analysis, 2012

In the BAU scenario, the high rate of increase in CO₂ emission from electricity generation mostly due to the increasing use of coal in power generation. From the mitigation point of view, the trend is disturbing since the power generation sector is likely to increase the emission intensity over time if coal continues to play an increasingly significant role in Malaysia's electricity generation mix.

The contribution to emission from the consumption of electricity in the various sectors in the BAU scenario is given in Figure 3.11.13.

¹²⁵ This includes CO₂ emissions from electricity generation, industrial sector, residential and commercial sector, transport sector, non-energy use sector and energy use in the agriculture sector

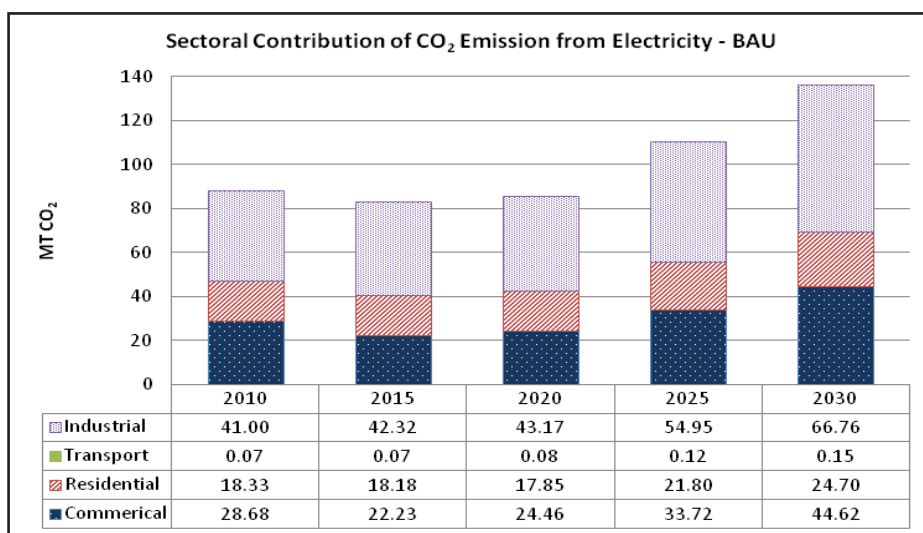


Figure 3.11.13: Sectoral contribution of CO₂ emissions from electricity – BAU scenario
Source: TERI Analysis, 2012

The emissions from electricity are the highest in the industrial sector followed by commercial and residential sectors. In the BAU scenario there is hardly any use of electricity in the transport sector and it is expected to grow only marginally over the modelling period.

3.11.1.2 Ambitious Scenario

In this section, the fuel consumption and the emissions in the ambitious scenario are discussed. The ambitious scenario includes various assumptions as described in the most ambitious alternative scenario discussed in each sector. This scenario provides an indication of what the Malaysian economy can achieve if such mitigation potential was achieved.

3.11.1.2.1 Primary Energy Supply in Ambitious Scenario

The total primary energy use in the Malaysian economy increases from 65,419 ktoe in 2010 to 92,555 ktoe in the ambitious scenario (Figure 3.11.14) as against the near doubling of primary energy use in the BAU scenario. As in the BAU scenario, petroleum products are the main source of energy throughout the projection period.

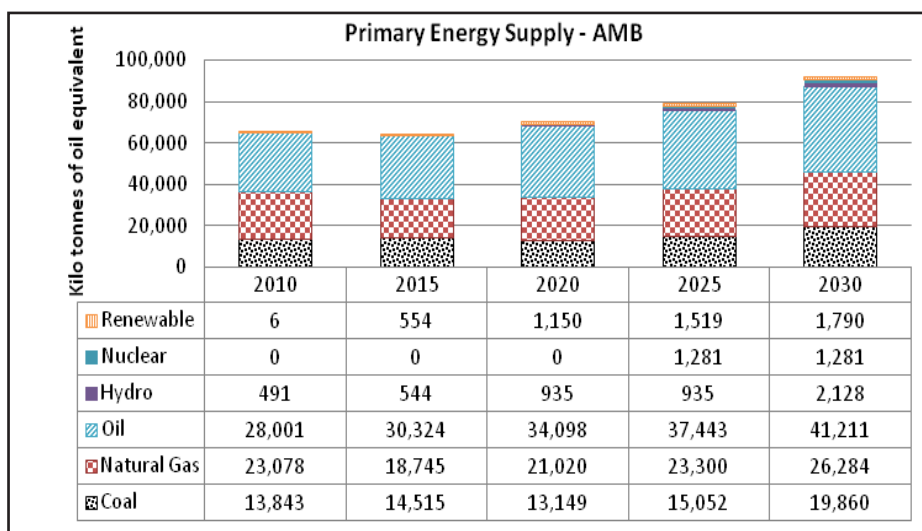


Figure 3.11.14: Primary Energy Supply – AMB scenario

Source: TERI Analysis, 2012

In the ambitious scenario, in addition to the reduction in primary energy supply (Figure 3.11.14) shift towards low carbon energy sources is also observed. For example, in ambitious scenario, zero carbon energy sources such as renewable, large hydro and nuclear contribute to around 6% to the commercial energy supply in 2030 while in the BAU scenario share for these sources is only 1% in the same year.

The comparison between the BAU and ambitious scenario in terms of primary energy supply is given in Figure 3.11.15.

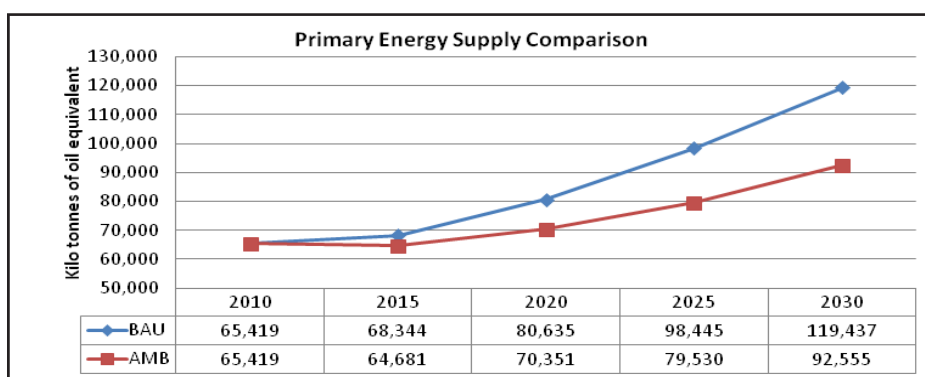


Figure 3.11.15: Comparison of Primary Energy Supply – BAU Vs AMB

Source: TERI Analysis, 2012

In the ambitious scenario in 2030 the primary energy supply is lesser by 23% as compared to the BAU.

The contribution of different fuels in power generation is given in Figure 3.11.16. As compared to BAU scenario, share of coal in total power generation is reduced. In the ambitious scenario, share of coal in total power generation in 2030 is 39% as compared to 62% in BAU scenario. This reduction is collectively attributed to increased share of renewable, nuclear, and natural gas in the ambitious scenario. Although the power generation in 2030 is almost same in both scenarios, generation capacity in the ambitious scenario is higher than the generation capacity in the BAU scenario as reflected in Figure 3.11.17. This is due to the fact that renewable energy has higher share in ambitious scenario (10% of generation capacity in 2030), which has lower capacity factor than the conventional power generation sources.

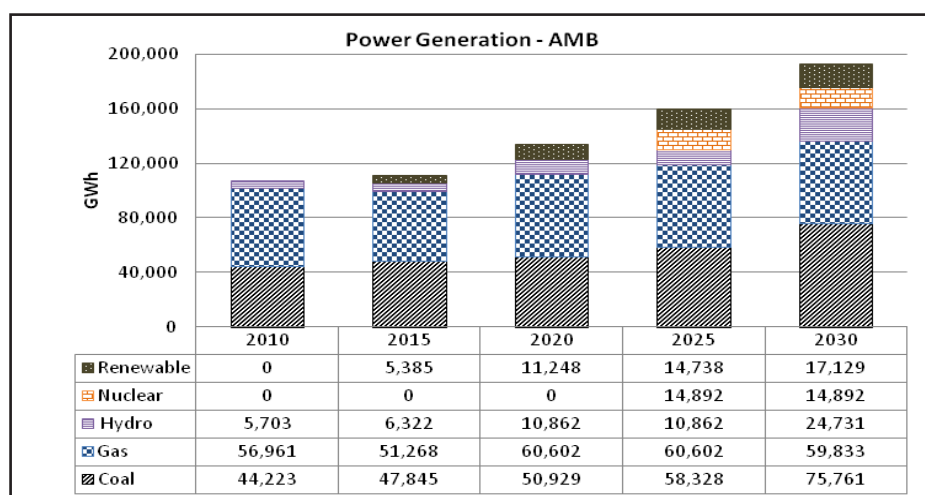


Figure 3.11.16: Power generation – AMB scenario

Source: TERI Analysis, 2012

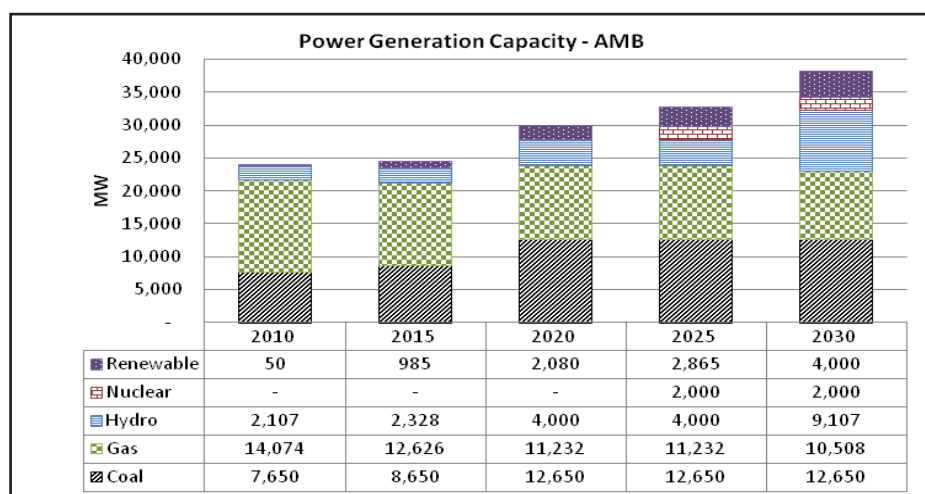


Figure 3.11.17: Power generation capacity - AMB scenario

Source: TERI Analysis, 2012

3.11.1.2.2 Final Energy Consumption in Ambitious Scenario

The total energy consumption in the BAU vis-à-vis AMB scenario is depicted in Figure 3.11.18. The ambitious scenario has 22% lower energy consumption in 2030 as compared to the Business-As-Usual Scenario which can largely be attributed to efficiency improvement across various sectors in the ambitious scenario.

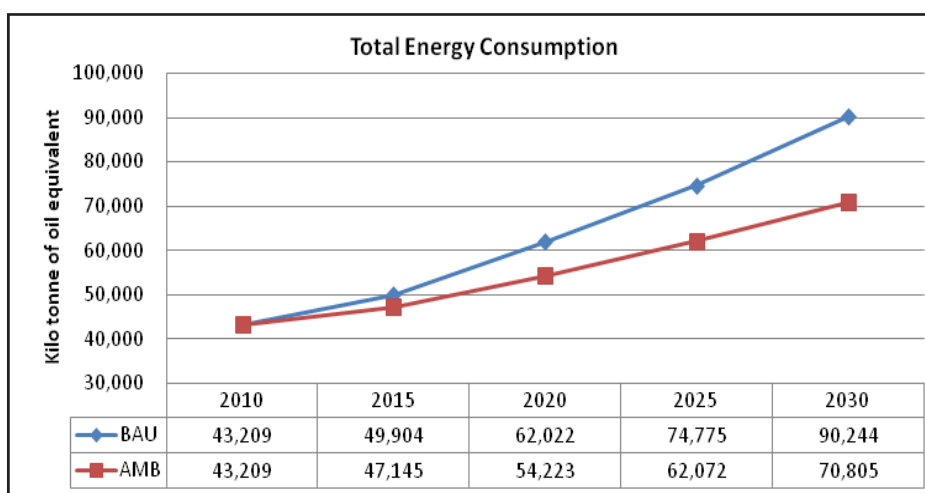


Figure 3.11.18: Comparison of total energy consumption – BAU Vs AMB

Source: TERI Analysis, 2012

The following sections examine the end-use fuel consumption across different sectors.

i. Transport Sector

In the transport sector, the following alternative cases were examined.

- TPT_RAIL: In this case, rail share is increased in total passenger and total freight movement vis-à-vis road
- TPT_PUB: In this case, the share of public transport is expected to increase
- TPT_EFF: In this case, the fuel efficiency is expected to improve every year in road transport by 1.5%
- TPT_ALT: In this case, the use of alternative and cleaner fuels is increased
- TPT_HYB: Incorporates all the above cases in the transport sector and forms ambitious scenario

Figure 3.11.19 shows the energy consumption in the transport sector under the various cases considered.

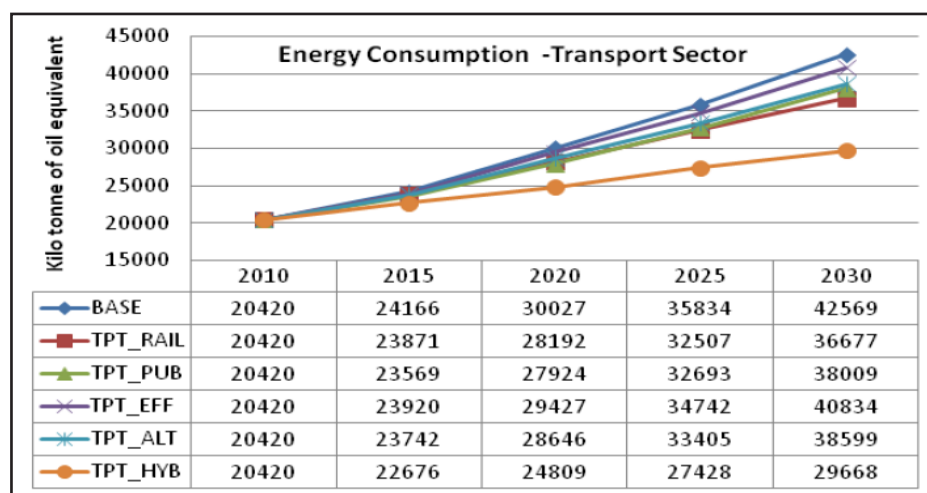


Figure 3.11.19: Comparison of energy consumption in transport sector – BAU Vs AMB
Source: TERI Analysis, 2012

In the Business-As-Usual scenario, the total energy consumption increases from 20,420 ktOE in 2010 to 42,569 ktOE in 2030.

In the case of TPT_RAIL, the share of rail in total passenger movement and total freight movement is assumed to increase to 10% by 2020 and 20% by 2030 and with rail being a more energy efficient mode, the total energy consumption in the transport sector reduces to 36,677 ktOE in 2030, a reduction by 13.8% as compared to BAU scenario.

In the case of TPT_EFF, the efficiency of road transport is assumed to improve by 1.5% and this resulted in reduction of total energy consumption in transport sector by nearly 4.08% as compared to BAU scenario.

When the share of public transport is expected to increase to 40% by 2020 and 50% by 2030, the total energy consumption in transport sector reduces from 42,569 ktOE in 2030 to 38,009 ktOE in 2030, a reduction of 10.71%. This is because of shifting people to more energy efficient modes of transport from personalised modes which generally consume more energy per passenger kilometre.

When the use of alternative and cleaner fuels is increased in the transport Sector (TPT_ALT), the energy consumption in the transport sector reduces by 9.3% in 2030 as compared to BAU scenario.

In a scenario, where all the above options are included together (TPT_HYB case or the ambitious scenario), the energy consumption reduces to 29,668 ktOE in 2030, as compared to 42,569 ktOE in 2030 in the BAU scenario, a reduction of 30.31%.

Figure 3.11.20 shows the fuel wise energy consumption in the TPT_HYB case or ambitious scenario.

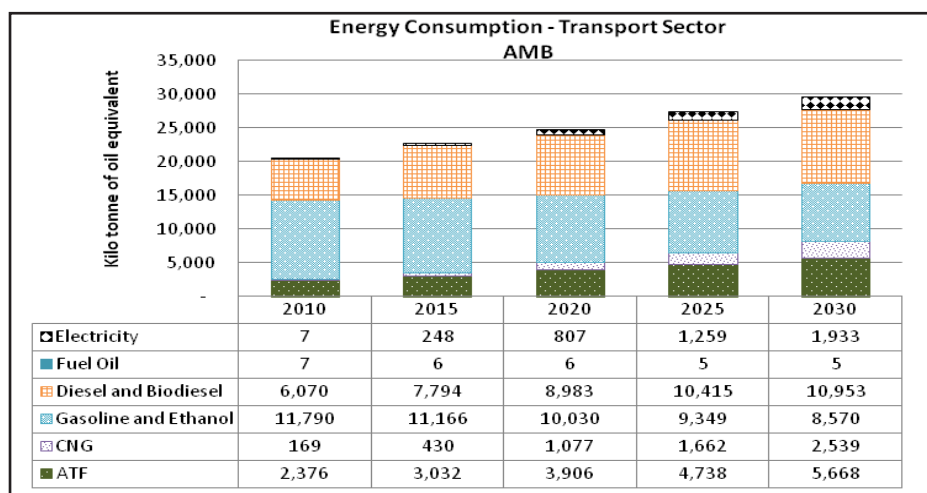


Figure 3.11.20: Energy consumption in transport sector – AMB scenario

Source: TERI Analysis, 2012

In the ambitious scenario, we notice that the share of gasoline in the total energy consumption in the transport sector reduces to 29%, whereas, the share of CNG increases to 9%, and the share of electricity increases to 7% by 2030. The share of diesel and bio-diesel becomes nearly 37% and the share of ATF becomes nearly 19% in this case by 2030. While in BAU scenario, shares of gasoline, CNG, electricity, diesel and ATF in the transport sector are estimated at 59%, 3%, negligible, 25%, and 13% respectively in 2030.

In absolute terms, the energy consumption based on gasoline reduces from 29,794 ktoe in BAU scenario to 8,570 ktoe in TPT_HYB case in the ambitious scenario in 2030, whereas it increases from 18 ktoe to 1,933 ktoe in case of electricity and from 1,119 ktoe to 2,539 ktoe in case of CNG by 2030. It must, however, be noted that a shift towards electricity bound transport is beneficial in the overall sense only if electricity generation could also shift to non-fossil fuels or cleaner fuels.

ii. Industrial Sector

In the ambitious scenario, as indicated in Figure 3.11.21, the total energy consumption in the industrial sector reduces to 21,185 ktoe in 2030 as compared to 24,368 ktoe in the Business-as-usual scenario, a reduction of nearly 13%, on account of energy efficiency improvements across various industrial subsectors.

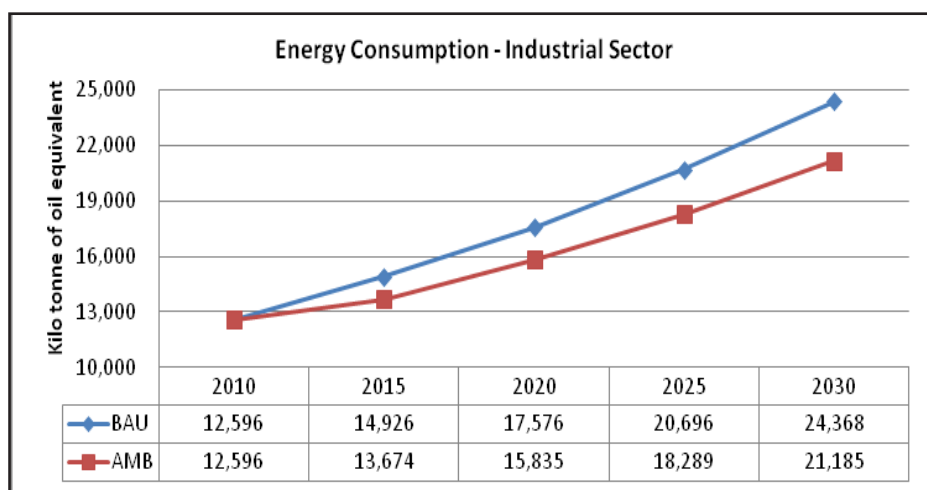


Figure 3.11.21: Comparison of energy consumption in industrial sector – BAU vs AMB

Source: TERI Analysis, 2012

Figure 3.11.22 shows the energy consumption, fuel wise in the ambitious scenario in industrial sector, when the efficiency is improved.

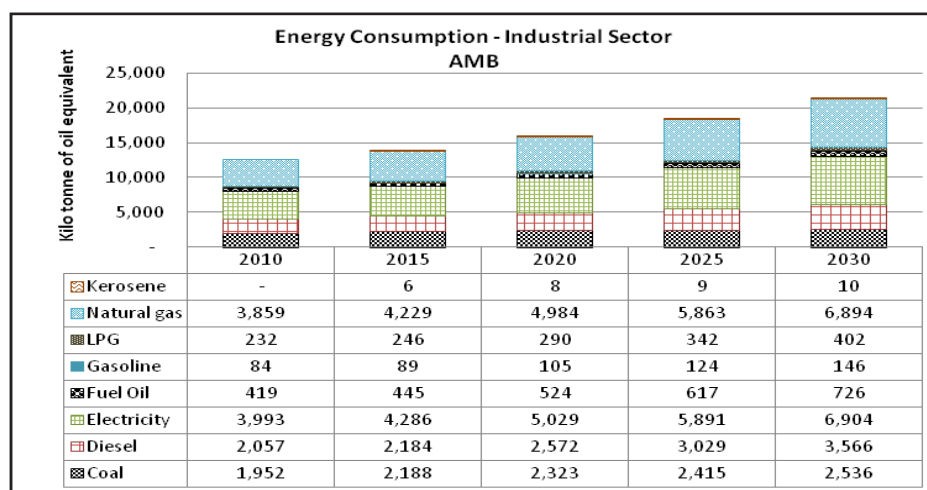


Figure 3.11.22: Energy consumption in industrial sector - AMB scenario

Source: TERI Analysis, 2012

While the level of disaggregation in the industrial sector does not permit a very detailed assessment of technologies, the industrial sector indicates a scope of some energy saving in the ambitious scenario, which can be brought about in the industrial sub sectors.

iii. Commercial Sector

In the ambitious scenario, the efficiency of appliances used in the commercial sector is assumed to improve as described previously in the report. Figure 3.11.23 shows the comparison of the energy consumption between the BAU and ambitious scenario for the commercial sector. In the ambitious scenario the energy consumption increases from 3,918 ktoe in 2010 to 8,030 ktoe in 2030 whereas in the BAU scenario it rises to 10,674 ktoe by 2030, showing a saving of around 25% in 2030.

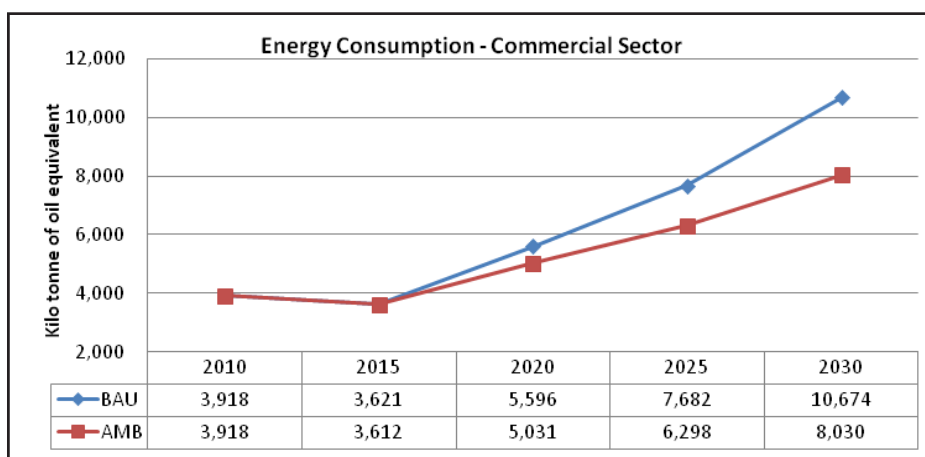


Figure 3.11.23: Comparison of energy consumption in commercial sector – BAU Vs AMB
Source: TERI Analysis, 2012

Figure 3.11.24 shows the energy consumption, fuel wise in the ambitious scenario in commercial sector. The scope for energy saving and efficiency improvement is largely in the use of electrical appliances used in the commercial sector.

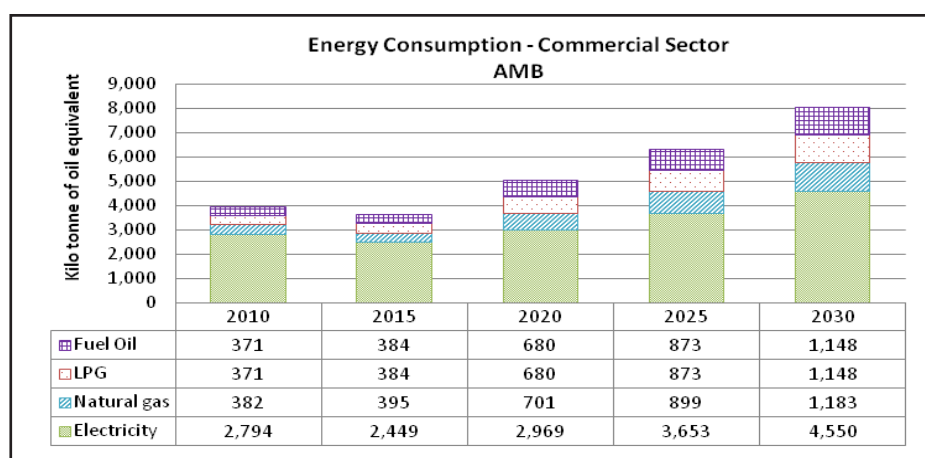


Figure 3.11.24: Energy consumption in commercial sector - AMB scenario
Source: TERI Analysis, 2012

iv. Residential Sector

In the ambitious scenario, with the improvement in the efficiency of appliances as described in the earlier sections, the energy consumption rises from 2,481 ktoe in 2010 to 3,180 ktoe in 2030 whereas in the BAU scenario it rises to 3,891 ktoe by 2030 (Figure 3.11.25). A saving of around 18% can be achieved by 2030. Given that the stock of appliances in the residential sector would be able to change gradually, much of the saving would accrue gradually and towards the later part of the modelling period.

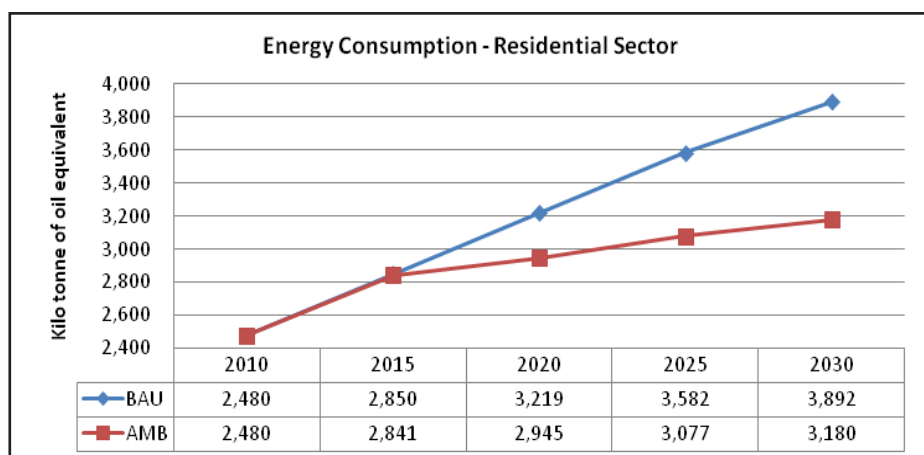


Figure 3.11.25: Comparison of energy consumption in residential sector – BAU Vs AMB
Source: TERI Analysis, 2012

Figure 3.11.26 shows the energy consumption, fuel wise in the ambitious scenario in residential sector, with greater penetration of efficient appliances.

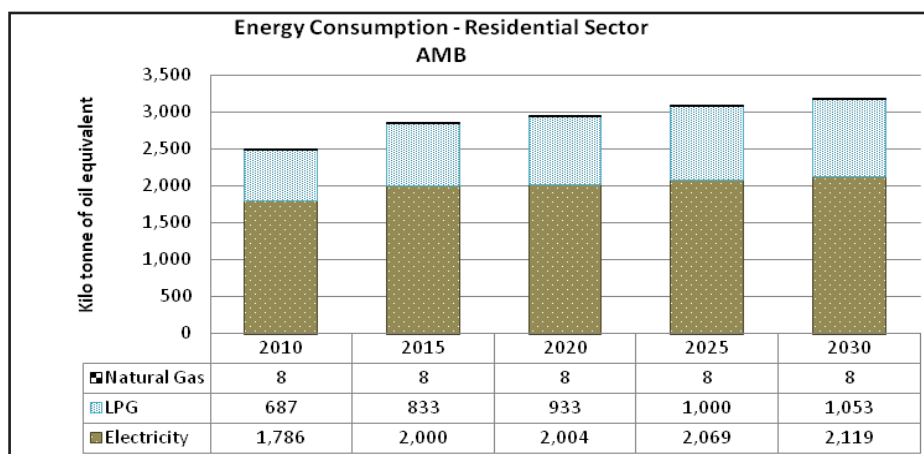


Figure 3.11.26: Energy consumption in residential sector – AMB scenario
Source: TERI Analysis, 2012

3.11.1.2.3 CO₂ Emissions in the Ambitious Scenario

The ambitious scenario includes a suite of aggressive actions across all sectors. Figure 3.11.27 compares the total emissions from the energy sector in the BAU and the ambitious scenario.

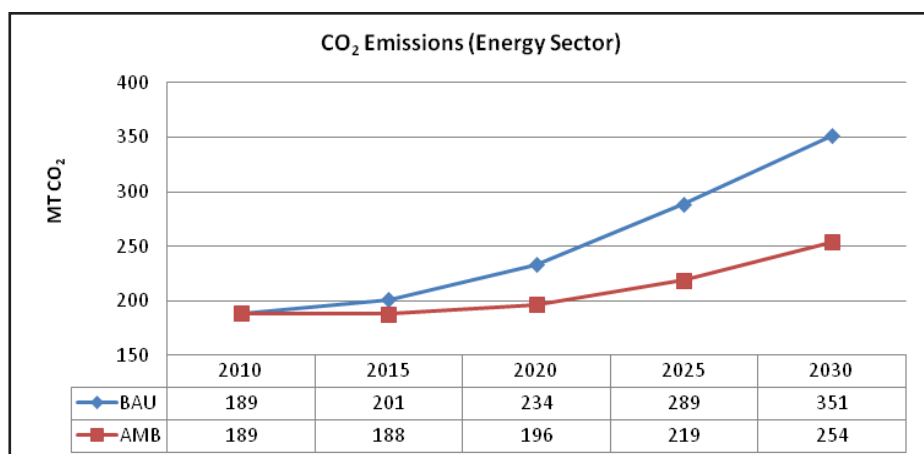


Figure 3.11.27: Comparison of total CO₂ emissions in the energy sector – BAU Vs AMB¹²⁶
Source: TERI Analysis, 2012

It is observed that the scope for emission reduction from the energy sector is fairly limited in the immediate short term (till 2015); by 2020, around 16% emission reduction can be achieved and by 2030, around 28%. Figure 3.11.28 shows the sector wise emissions in the ambitious scenario.

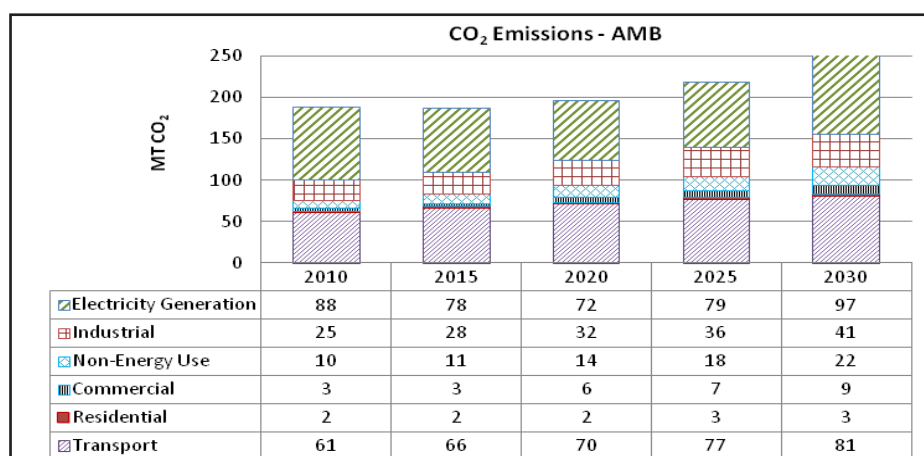


Figure 3.11.28: Sector wise CO₂ emissions – AMB scenario
Source: TERI Analysis, 2012

¹²⁶ This includes CO₂ emissions from electricity generation, industrial sector, residential and commercial sector, transport sector, non-energy use sector and energy use in the agriculture sector.

Electricity generation, transport and industrial remain the main sectors accounting for CO₂ emissions as well as having the potential for emissions reduction. Accordingly, demand side measures which are often win-win in the long term need to be considered as indicated in the ambitious scenario. However, additional efforts need to be made from the energy supply side in bringing about emission reduction. The contribution of the various fuels to the total emissions is given in Figure 3.11.29.

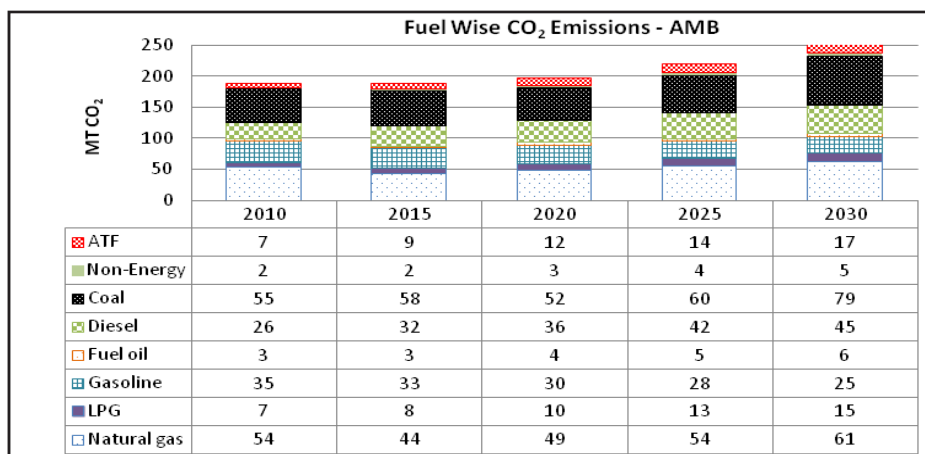


Figure 3.11.29: Fuel wise CO₂ emissions – AMB scenario

Source: TERI Analysis, 2012

The fuel wise emission analysis also indicates that the potential for moving away from fossil based fuels in the energy sector seems to be rather limited. A more determined push or effort to include zero carbon fuel options into Malaysia's energy mix would need to be made to enable significant changes in emission in the energy sector.

The emissions from the power sector for the BAU and the ambitious scenario are given in Figure 3.11.30.

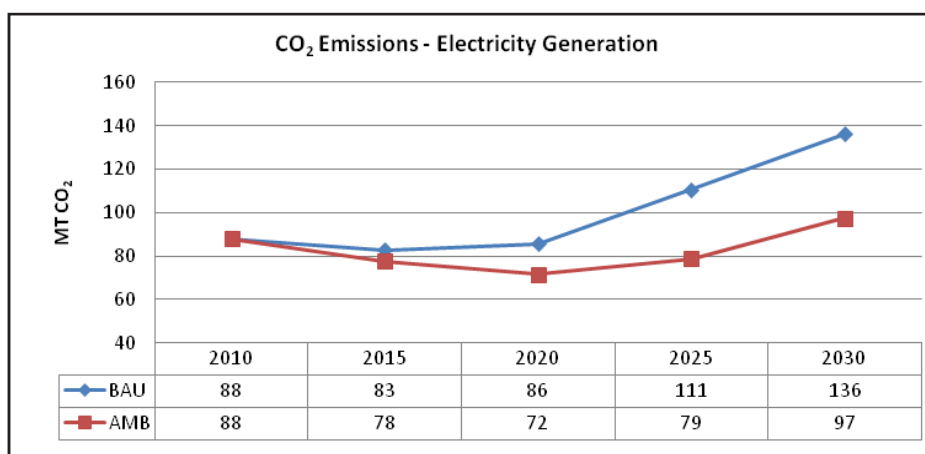


Figure 3.11.30: CO₂ emission from electricity generation

Source: TERI Analysis, 2012

In the ambitious scenario the CO₂ emissions from electricity generation are lower by 16% and 28% as compared to BAU in 2020 and 2030 respectively. The lower emission can be attributed to higher use of renewable energy, nuclear energy as well as proportionally higher use of gas based generation.

The ambitious scenario while being able to constrain the growth rate of emissions is however, not an extremely stringent scenario in terms of mitigation. The degrees of freedom for reducing power sector emissions are low in the short to medium term. However, in the long term there is a clear need to consider clean fuels/renewables and the fuel diversification policy may be further strengthened to focus on research and development and evaluations in this regard.

The emissions from the power sector can be attributed to the various sectors based on their consumption of electricity. The contribution to emission from the consumption of electricity in the various sectors in the ambitious scenario is given in Figure 3.11.31.

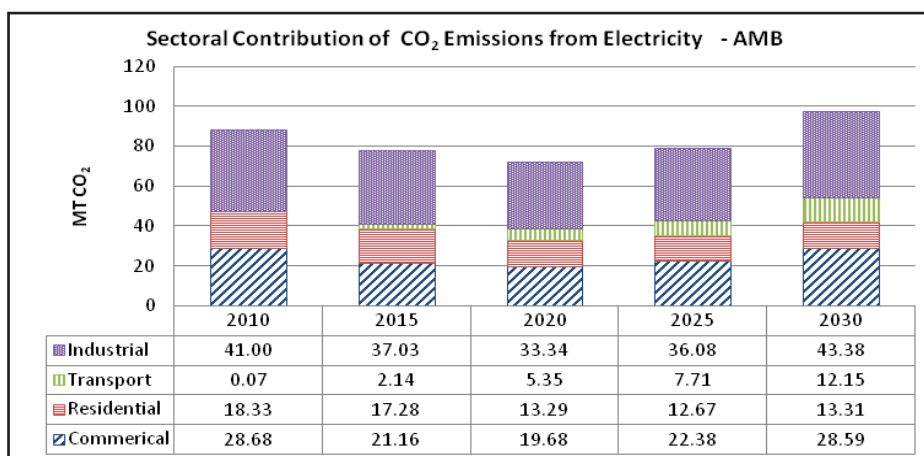


Figure 3.11.31: Sectoral contribution of CO₂ emissions from electricity - AMB scenario
Source: TERI Analysis, 2012

Unlike in the BAU in the ambitious scenario the share of emissions from the transport sector in the electricity generation is comparatively higher as the transport sector assumes a substantial shift towards electricity powered vehicles.

Figure 3.11.32 shows the emissions from the transport sector in various cases. The emissions from the transport sector reduce from 125 MtCO₂ eq. in 2030 in the BAU Scenario to nearly 81 MtCO₂ eq. in 2030 in the TPT_HYB case or ambitious Scenario.

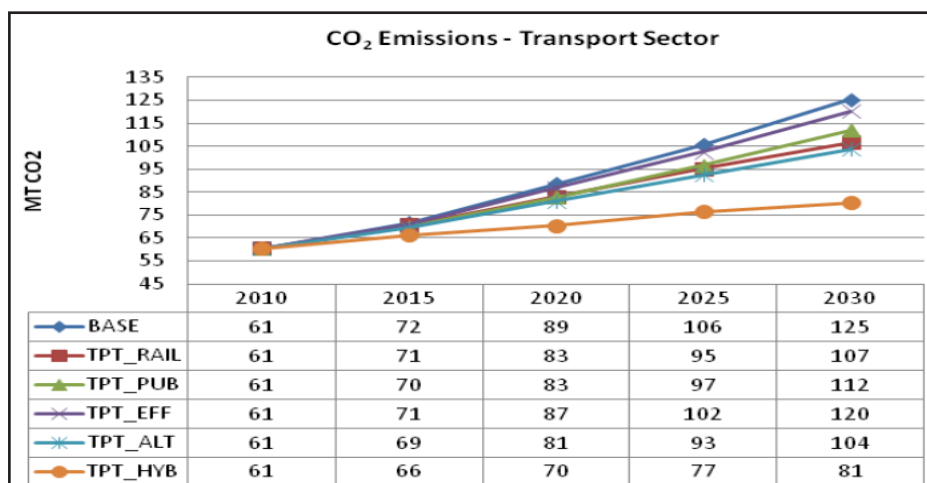


Figure 3.11.32: CO₂ emissions from transport sector

Source: TERI Analysis, 2012

Table 3.11.2 gives the reduction in emissions in the transport sector in various cases.

Table 3.11.2: CO₂ emissions reduction from transport sector (MtCO₂ eq.)

Scenario	2020	2030
TPT_RAIL	6	19
TPT_PUB	6	13
TPT_EFF	2	5
TPT_ALT	8	22
TPT_HYB	18	45

Source: TERI Analysis, 2012

In the ambitious scenario, the emissions from the transport sector reduce from 125 MtCO₂ eq. (in the BAU Scenario) to nearly 81 MtCO₂ eq. (in TPT_HYB case or AMB scenario) in 2030.

The CO₂ emissions from fuel use in the industrial sector in the BAU Scenario and the AMB Scenario are given in Figure 3.11.33. The emissions reduce from around 49 MtCO₂ eq. in the BAU scenario to nearly 41 MtCO₂ eq. in the AMB Scenario in 2030.

Detailed assessment of the potential across various units and sectors should however be taken up subsequently through energy audits and sub-sectoral assessments.

The mitigation technologies in residential sector are mostly electrified apart from the LPG, kerosene and natural gas cook stoves. Thus, the emission savings due to efficiency improvements in the AMB scenario as compared to the BAU scenario are reflected in terms of emission savings from the power sector.

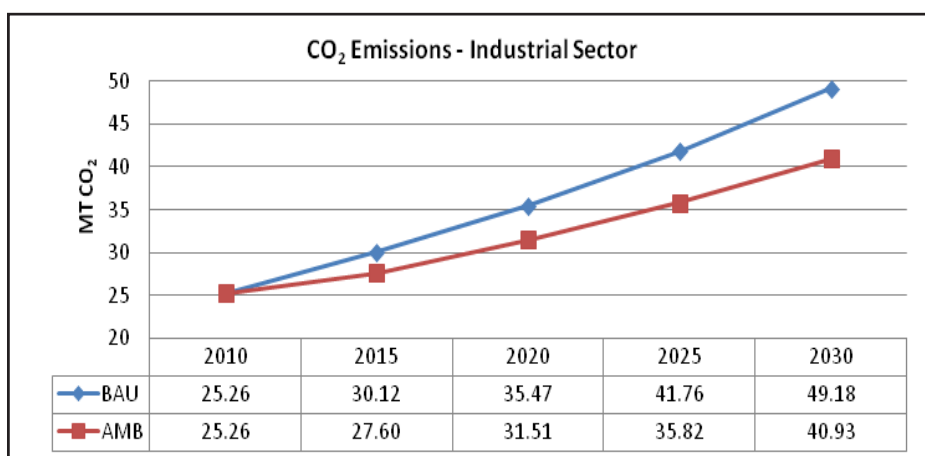


Figure 3.11.33: CO₂ emissions from industrial sector

Source: TERI Analysis, 2012

Unlike the residential sector, the commercial sector has a higher usage of fuels other than electricity. As a result the scope for mitigation in the commercial sector is also reflected as energy savings in the sector. Figure 3.11.34 shows the emissions from the commercial sector (on account of fuels other than electricity) both in the BAU and AMB scenario.

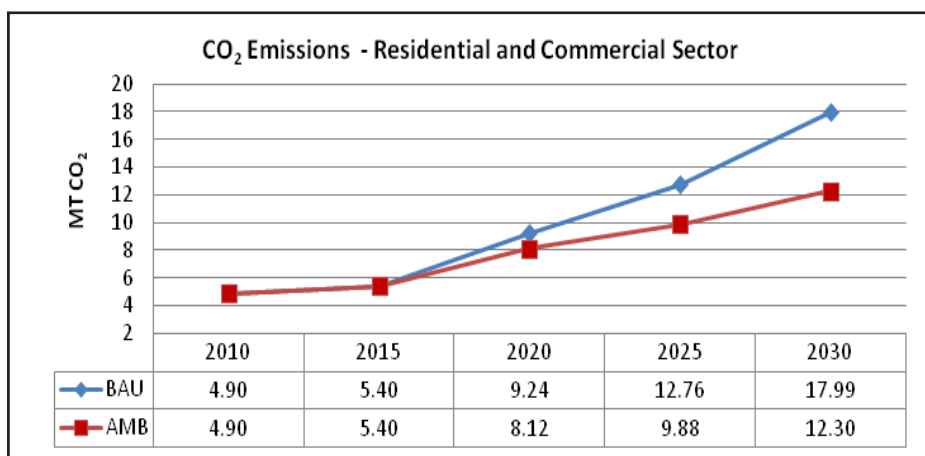


Figure 3.11.34: CO₂ emissions from residential and commercial sector

Source: TERI Analysis, 2012

The emissions from the residential and commercial sectors increase from 5 MtCO₂ eq. in 2010 to 18 MtCO₂ eq. in the BAU scenario in 2030 and to 12 MtCO₂ eq. in the ambitious scenario in 2030. The ambitious scenario achieves a 32% reduction in CO₂ emissions when compared to the BAU scenario. This reduction is achieved by the implementation of more efficient technologies as new construction comes under the ambit of the Green Building Index (GBI).

3.11.2 Recommendations

Based on the analysis of the energy sector emissions and mitigation potential and drawing on the knowledge / learning of barriers, opportunities and policies in Malaysia, this section provides recommendations for each of energy demand and supply sector.

3.11.2.1 Recommendations for the Transport Sector

To reduce the emissions from the transport sector, there is a need to opt for various technological and policy measures and interventions aimed at:

- i. Shifting the passengers and freight from energy inefficient modes of transport to energy efficient modes.
- ii. Reducing the demand for personalized modes of transport.
- iii. Improving the technology/efficiency of vehicles.
- iv. Increasing use of alternative fuels/ renewable and cleaner sources of energy.

The options for these are discussed in the following section:.

3.11.2.1.1 Increasing Share of Rail in Passenger and Freight Movement

The share of rail in the total freight movement and total passenger movement is marginal. Some of the short term, medium term and long term measures to increase the share of rail in total passenger and total freight movement are given below.

(a) Short Term

- i. *Procurement of coaches, locomotives, wagons*
There is a need to examine the potential to manufacture coaches, wagons and locomotives and enhance the capacity.
- ii. *Analyse commodity movement for right marketing strategies*
In case of freight movement, it is important to study the trend of commodity movement by rail. The total freight carried by railways declined from nearly 1,602 million tonne kilometres in 1995 to 846 million tonne kilometres in 2000 but again increased to 1,483 million tonne kilometres in 2010. As far as the composition of traffic is concerned, cement and clinker, maritime containers are the two major commodities moved by rail. The rail traffic is getting concentrated to a few commodities. There is a need to analyse the commodity movement, demand pattern and availability of rolling stock for developing right marketing strategies.

(b) Medium Term

- i. *Enhancing Capacity of Rail – expansion of network*
There is a need to increase the pace of investment in rail infrastructure so that there are no constraints from the supply side or due to lack of infrastructure. The possibility to increase the route kilometres needs to be explored. New lines may be constructed particularly on high density routes. A detailed study and analysis is required for that.

(c) Long Term

- i. *Identify corridors with high density and do feasibility studies for high speed rail – increase the pace.*

There is a need to study the reasons for people shifting to other modes. Speed and frequency are some of the major problems. Therefore, increasing the frequency of trains or reducing the stoppage time are some of the other options to increase the share of rail. Introduction of high speed rails can shift a lot of traffic from road and air to rail. High density routes need to be identified and capacity should be augmented. There is a need to go for increasing feasibility studies for this.

3.11.2.1.2 Reducing the Demand for Personalized Modes of Transport and Increasing Share of Public Transport

The share of public transport is fairly low in Malaysia. Figure 3.11.35 shows the share of passenger movement by motor cars and motor cycles in total passenger movement by road.

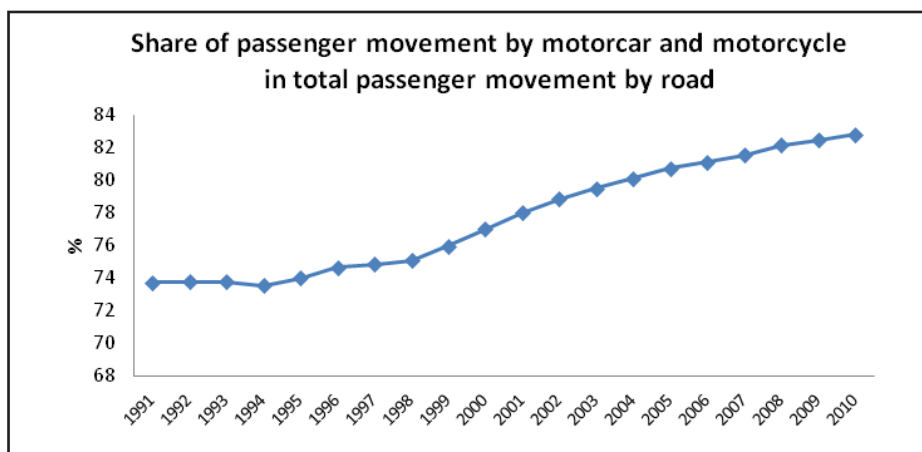


Figure 3.11.35: Share of passenger movement by motor car and motor cycle in total passenger movement by road

Source: MOT, UM, PTM

The government needs to adopt policies that help in increasing the share of public transport. Some of the short term, medium term and long term measures for this are given below.

(a) Short Term

- i. *Capital Subsidy for Buses*

There is a need to improve the quality of bus services and identify the needs for capacity augmentation if there are problems of overcrowding. Providing capital subsidies for buses can lead to increase in capacity.

ii. *Improve connectivity and accessibility unserved areas*

There is a need to improve the accessibility as well as connectivity and serve the un-served areas. Many people are not able to use the public mode even if there is enough capacity, due to lack of connectivity and reliability of public service. To improve the connectivity to these systems, feeder services should be provided in un-served and underserved areas. If the connectivity and accessibility is improved, there is a possibility to shift a lot of passengers from other modes to this.

iii. *Taxes and Duties on vehicles*

Imposing high duties on vehicles would increase the prices of vehicles and increase in price of vehicles can help in reducing the sales of automobiles and shift people to other modes. However, this is possible only when other options for public transport are available. There is a need to study the possible impact of that.

iv. *Congestion pricing and tolls*

The area Licensing Scheme was also proposed as one of the components of the Second Urban Transport Project. In November 1978, thirteen steel gantries were erected by City Hall as a preparation for implementing the ALS but it was rejected in May 1979. The major reasons for this were inadequacy of public transport to cater to the increased demand, inadequacy of park and ride facilities for private car commuters wishing to shift to public transport and no provision of an alternative route then.

It is important to improve the condition of public transport. Once adequate public transport is provided, then such schemes can be tried in some areas. Congestion pricing has also been introduced in London. There is a need to study the travel pattern and the infrastructure before implementation of such a scheme.

v. *Vehicle quota system*

The vehicle quota system determines the exact number of vehicles of various categories allowed on road. This limits the increase in number of vehicles on road. This was introduced in Singapore in 1990. The motor vehicle buyers have to obtain a quota license, called a certificate of entitlement before they are allowed to make their purchase. It is valid for 10 years.

Box 3.11.1: Vehicle quota system in Singapore

Each year, the quota for new vehicles is determined so as to obtain a target rate of growth in the total motor vehicles population. The quota formula is as follows:

(Total motor vehicle quota) $q_y = g \cdot (\text{Motor Vehicle Population})_{y-1} + (\text{Projected de-registrations})_y + (\text{Unallocated quota})_{q_{y-1}}$

Here, the subscript y denotes the calendar year and q_y denotes the quota year. The outcomes of this are as under:

Growth Rate of Motor Vehicles in Singapore

Period	Average Annual Motor Vehicle Growth Rate (%)	Standard Deviation (%)
1975-89	4.4	4.24
1990-99	2.9	2.06

Source: Rationing Rules and Outcomes: The Experience of Singapore's Vehicle Quota System

This shows that VQS was successful in lowering the average annual growth rate of motor vehicle growth and its volatility.

It may be necessary to examine if such a quota regime can be introduced in Malaysia. This could lower down the rate of growth of vehicles. But once purchased, it may not be able to decrease or lower down the usage of these vehicles.

vi. *Fuel pricing*

The fuels in Malaysia are highly subsidized and this can be one of the main reasons for increased usage of petroleum fuels. There is a need to study and analyse the fuel prices with a view to reduce the energy consumption.

(b) Medium Term

i. *Increasing capacity of LRT, Monorail and other rail based modes*

Systems like LRT, Monorail and other rail based are expected to shift a lot of traffic from road to rail. It has been introduced in many other places like Hong Kong, Germany, etc. Freiburg city in Germany has a highly efficient light rail transit system. It is Germany's environmental capital and most sustainable city (Buehler et al, 2011). Expanding light rail transit was an integral part of the strategy to integrate public transport and land use planning. While Malaysia has already proposed focusing on increasing capacity of LRT, monorail, etc, these need to be strongly pursued, while keeping in mind their possible implications on power sector emissions.

The expansion of the infrastructure will support one of the principles stipulated in the National Physical Plan; that favour public transport over private vehicle use for inter-urban and intra-city movement. However, it is also important to study the energy efficiency and emission from these.

(c) Long Term

i. *Improving planning of cities so as to reduce demand for transport*

There is a relationship between distribution of land use pattern and transport demand. The land use pattern has to be designed in an integrated manner so as to reduce the demand for travel.

ii. *Intelligent transport system*

Proper traffic management and use of intelligent transport system can also help reduce a lot of problems.

3.11.2.1.3 Improving the Technology/Efficiency of Vehicles and Emission Standards

(a) Short Term

i. *Fuel economy standards*

Fuel economy standards can help create awareness and guide the consumers in making decisions in purchasing vehicles. This also encourages the manufactures to come up with better fuel economy vehicles.

Such standards have been introduced by some other countries as well. The US was the first country to establish fuel economy standards for passenger vehicles after the 1970 oil crisis. It is the Corporate Average Fuel Economy (CAFÉ). Other countries such as China, Japan, European countries and the state of California in the US have established tightened GHG or fuel economy standards.

Fuel economy standards can be introduced in Malaysia and there should be proper monitoring and inspection of vehicles. There is a need for a detailed study and analyses in this area.

(b) Medium Term

- i. *R&D activities – improving efficiency of vehicles*
Support from the government in terms of funding/ providing financial support to the Research and Development activities in areas like efficiency improvement of vehicles can help.
- ii. *Labelling of vehicles*
Labelling of vehicles can also help new car purchasers in making decisions by raising their awareness in fuel efficiencies of various models of vehicles. This will also bring in competition between car manufacturers and encourage them to improve their product. Fuel economy labels should be made mandatory. However, there is a need for further detailed studies in this regard.

3.11.2.1.4 Increasing Use of Alternate Fuels/ Renewable and Cleaner Sources of Energy

(a) Short Term

- i. Mandatory use of bio-fuels/ alternate fuels

CNG

The penetration of natural gas in the transport sector is very limited in Malaysia. There is a need to diversify the fuel basket and increase the penetration of this fuel since Malaysia is a significant producer of natural gas and is the third largest exporter of liquefied natural gas after Qatar and Indonesia.¹²⁷ Argentina has a large fleet of CNG converted vehicles and refuelling stations.¹²⁸

Bio-diesel and Bio-ethanol

The usage of bio-fuel should be increased in the transport sector. Use of bio-diesel and bio- ethanol should be promoted. The government should set up targets for usage of these fuels. Some incentives schemes could be provided such as reduction in taxes for vehicles using such fuels. The National Bio-fuel Policy was launched by the government in 2006. The policy was primarily aimed at reducing country's dependence on depleting fossil fuels. The impact of such policies needs to be evaluated.

¹²⁷ Source: US Energy Information Administration.

¹²⁸ Source: Galileo Natural Gas Technologies, Argentina

Vegetable oil can be used to produce bio-diesel. Also, Malaysia is one of the largest producers and supplier of palm oil. Palm oil can be used for production of bio-diesel. One of the main advantages of using palm oil as bio-fuel as mentioned by Hanafi et al. is its annual oil yield per hectare. This means that with less cultivated area, oil palm can produce much oil thus can save much arable land to be used to cultivate other crops. It is also an energy efficient crop (Hanafi et al., Universiti Teknologi Malaysia).

Bio-ethanol was introduced in Nanyang. It is one of the demonstration cities in EU funded BEST (Bio-ethanol for Sustainable Transport) project. The demonstration started in June 2002. In October 2003, petrol stations shifted from supplying petrol to E10. Petrol cars and motorcycles in Nanyang are using E10 ¹²⁹. Bio-ethanol is being used in Thailand. Thailand has a 15 year Alternative Energy Plan.

Box 3.11.2: 15 Year Alternate Energy Plan: Thailand

Short Term (2008-2011):

Focussing on promoting the proven alternative energy technologies with high potential sources such as bio-fuels, heat, power generation from biomass and bio-gas. The financial support measures will be fully implemented.

Medium Term (2012-2016):

Promoting the alternative energy technology industry and supporting the development on new prototype of alternative energy technology for higher cost effectiveness. This includes promoting new technologies for bio-fuel production.

Long Term (2017-2022):

Promoting new technologies of alternate energy which are cost effective. Supporting Thailand to become the hub of bio-fuel export and exporting the alternative technology in the ASIAN region.

Source: Sustainability Assessment of a Sugar Bio-Refinery Complex in Thailand, Dr. Shabbir H Gheewala, Professor, The Joint Graduate School of Energy and Environment, Thailand

Sweden has a long experience of ethanol buses. The ethanol buses were introduced in the city bus fleet by The Stockholm Public Transport Authority in the middle of 1980s. Since then, there has been successful replacement of diesel buses by ethanol buses (Atler-motive, 2011).

There has been increased attention given to biofuels in Indonesia as well. Mandatory targets have been introduced. It is important to focus on second generation bio-fuels. Other options need to be explored for e.g. waste cooking oil to produce second generation bio-diesel.

Electricity

Electrification of railways can also reduce the dependency on diesel. Hybrid vehicles and electric vehicles are being introduced by companies such as Honda's Civic Hybrid, Toyota's Prius, and Lexus model CT 200h.

¹²⁹ Source: BEST Deliverable No. 2.07, March 2010, Nanyang

The national car manufacturer, Proton, is working on hybrid and electric vehicles to replace regular internal combustion engines. Although, it is in process of developing electric and hybrid cars since 2004, there have been many obstacles. Some of these being high cost of technology, lack of scale to lower production costs, lack of infrastructure and highly subsidized fuel in Malaysia ¹³⁰.

The use of electricity should be increased in the transport sector provided the fuel mix used to generate electricity uses alternate fuels and renewable and clean sources of energy.

ii. Tax Incentives

Providing fiscal incentives is another option. Tax incentive schemes could be introduced for high efficiency vehicle technologies. In Budget 2012, the Malaysian Prime Minister announced that 100% exemption of import duty and excise duty for new CBU hybrid and electric cars would be extended for another two years. The exemption was earlier given for only one year. This led to increased sales of Honda Insight and Toyota Prius in Malaysia ¹³¹. This action is expected to be a catalyst in promoting local assembly of hybrid and electric cars in the country.

On the other hand, tax incentives could be given to encourage use of CNG or for purchasing new buses. Detailed study and analysis is required for this.

(b) Medium Term

i. Investment in CNG infrastructure

It is important to increase the usage of CNG in the transport sector. However, before going for any policy in that direction, it is important to expand the gas distribution network and provide adequate infrastructure and re-fuelling stations to meet the demand of the people. Development of CNG engines should be there and incentives should also be provided to people using CNG.

ii. Investment in R&D e.g. hydrogen fuel cells

Encouraging manufacturers to invest more in R&D or providing funding for advanced technology research could help.

(b) Long Term

i. Investment in infrastructure of electric vehicles

There is a need to increase the investment in infrastructure for use of electric vehicles and to provide enough charging stations.

¹³⁰ Green Impact: Low carbon Green Growth, Ministry of Energy, Green Technology and Water, in collaboration with Green Purchasing Network Malaysia

¹³¹ Source: paultan.org

ii. Investment in Hydrogen fuel cells infrastructure

With reduced dependence on fossil fuels and reduced emissions, the benefits from this technology are substantial.

The potential offered by hydrogen based fuel is also huge in Malaysia. Malaysia is in a position of becoming a lead producer of this fuel from methane effluents, given that it is the largest producer of crude palm oil in the world ¹³².

There is a need to focus on infrastructure to supply hydrogen. In a study conducted by Kamarudin et al. (2009), a big obstacle in adoption of hydrogen fuelled vehicles is the lack of a hydrogen delivery infrastructure. A full scale hydrogen infrastructure with production facilities, distribution chains and refilling stations is very expensive to construct. Detailed study and research is still required in this area.

Box 3.11.3: Benefits and Challenges of fuel cell Vehicles

Benefits

- Less Greenhouse Gas Emissions
- Less Air Pollutants
- Reduced Oil Dependence

Challenges

- On-board Hydrogen Storage
- Vehicles Cost
- Fuel Cell Durability and Reliability
- Getting Hydrogen to Customers
- Public Acceptance

Source: Energy Efficiency and Renewable Energy, US Department of Energy

iii. Improve plant mix for electricity generation in Malaysia

There is a need to improve the plant mix for generation of electricity in Malaysia. It should use more renewable and clean sources of energy.

3.11.2.1.5 Other Options

(a) Water Transport

It is important to identify the potential of water transport and augment the capacity where required and utilize it. The port industry needs to be promoted and the ferry terminals need to be upgraded to encourage people to use them.

The potential of barge carriers need to be explored. There is a need to study and analyse the potential and the impact in terms of energy, emission and cost in detail.

¹³² Green Impact: Low carbon Green Growth, Ministry of Energy, Green Technology and Water, in collaboration with Green Purchasing Network Malaysia

(b) Non-motorized transport

People should be encouraged to use non-motorized transport. Bicycles can be used for short distances which have no fuel consumption and emissions. However, the issue of safety needs to be addressed. It is one of the major issues in urban transport. The Malaysian Institute of Road Safety Research has been set up by the government in 2007.

Table 3.11.3 shows pedestrian injuries in Malaysia in the last few years.

Table 3.11.3: Pedestrian injuries

Injury Type	2005	2006	2007	2008	2009	2010
Fatal	601	595	636	598	593	626
Serious Injury	747	711	672	617	613	516
Light Injury	2,175	1,493	1,430	1,184	1,171	1,019

Source: Malaysian Institute of Road Safety Research

The road deaths increased from 6,200 in 2005 to 6,872 in 2010 (Malaysian Institute of Road Safety Research). There is a need to address the reasons for the existing fatalities.

Pedestrian network should be developed along the train corridors and bus stops and the connectivity should be improved. Sufficient number of crossings should be there. This also depends on the local conditions and requirements.

Dewan Bandaraya Kuala Lumpur (DBKL) and the private sector have initiated programmes to construct 4.5 kilometres of covered and elevated pedestrian linkages in the city centres with an expected completion date of mid 2012. A long-term plan will also be developed by DBKL to deploy a full pedestrian network across KL city totalling 45 kilometres. It is expected to be completed by 2014. Total funding requirements are estimated to be RM 105 million from 2011 to 2020 and the potential GNI impact is estimated to be around RM 6 million annually (ETP, Chapter 5).

Traffic conditions need to be regulated so that it is easier for pedestrians and bicyclists to travel. Pedestrian Priority Zones could be there like in Republic of Korea. In these zones, there is a travel speed limit of 30 Km/h, traffic calming measures and parking is prohibited except in designated areas. Also, 'Day of Pedestrians' is observed to encourage walking¹³³.

¹³³ Source: Green Impact: Low Carbon Green Growth, KeTTHA

3.11.2.2 Recommendations for the Industrial Sector

The industrial sector is expected to implement measures for improvements in equipment and processes as well as end uses. The roadmap on enhancing energy efficiency in the industrial sector can be put under the following broad heads:

(a) Strengthening the institutional structure to promote energy conservation

Energy efficiency activities in Malaysian industry can be institutionalized through the enactment of appropriate legislations and encouragement of the large energy intensive users to switch to energy efficient technological options. New industries should be encouraged to adopt the state of the art technologies that are energy efficient and environmentally sustainable. The process of institutionalization could include setting up of separate agency or strengthening an existing agency to promote energy conservation through various means. The provisions should include various measures like identifying large consumers i.e. those industrial consumers, which have energy consumption above a certain threshold level and developing specific programmes, either voluntary or mandatory for such consumers to reduce their energy consumption within a specified time period. Such measures can be accompanied by incentives that would encourage the industries to switch over to energy efficient technologies and best operating practices. The provisions can include mandatory clauses like getting energy audits done by accredited auditors on a regular basis, appointment of energy managers, regular reporting of energy consumption through online systems, etc. Specifically, the government of Malaysia can consider a programme aimed at promotion of energy auditing for large industrial consumers. This should include:

- i. Establishment of standardized energy auditing procedures, energy audit tools and energy management systems at plant level
- ii. Conducting energy audits for selected industrial sectors
- iii. Evaluation of the results and impacts of the auditing programme and
- iv. Development of sustainable follow-up mechanisms for each industrial sub-sector.

The energy efficiency institutional structure should be comprehensive and should promote implementation of the energy conservation policies in the country. It should include activities like:

- i. Taking necessary measures to create mass awareness and disseminate information
- ii. Arranging and organizing training of industry personnel and specialists
- iii. Strengthening consultancy services including Energy Service Companies
- iv. Promoting R & D and linkages between academia and industry
- v. Promoting development of standards for energy efficient (or super-efficient) appliances and products and facilitating adoption of such standards in Malaysia, which are comparable to the global standards. This can include incentives and programmes to companies to start manufacturing such appliances and products.
- vi. Formulating and facilitating implementation of pilot projects and demonstration projects for energy efficient technologies
- vii. Promoting innovative financing of energy efficiency projects

- viii. Preparing educational curriculum on efficient use of energy and its conservation in industries for use by selected engineering colleges and universities. This will help in ensuring that the students who graduated from engineering colleges have basic knowledge of energy conservation, thus helping in building a cadre of energy professionals for the long-term.
- ix. Implementing international cooperation programmes relating to efficient use of energy in industrial sector

(b) Development and demonstration of cleaner technologies for SMEs

The phenomenal growth of the industrial sector in Malaysia over the past three decades has led Small and Medium Enterprises (SMEs) into occupying an important position in the Malaysian economy. There are many industrial sectors like food processing, engineering industries, pulp and paper, rubber, etc., where SMEs exist in large numbers. Development policies can be re-looked so as to increase SME's competitiveness through adoption of energy efficient technologies. Amongst other factors, support measures for SMEs should include human resources development and financing linkages to enable them to invest in technological up-gradation.

Research, Design and Development (RD&D) is ideal for small-scale industrial sector. The government of Malaysia can launch specific sectoral programmes for SME sector that are aimed towards technology up-gradation and improvement of energy efficiency. These programmes must be industry specific as each SME sub-sector is unique in terms of technology, products, operating practices, etc. The interventions in different energy intensive SME sub-sectors would require technology and needs assessment, demonstration of technological options to suit local conditions and building local capacities for wider adoption by the units.

(c) Harnessing the potential of Cogeneration

Cogeneration has not been actively encouraged in the industrial sector of Malaysia. Since the IPP development in the 1990s, no direct policy and legislation has been in force to promote cogeneration. Incentives can be considered for companies to adopt advanced/efficient cogeneration systems. This would require initiating soft studies for various sectors like palm oil, chemicals, etc., to study the existing cogeneration systems that exist in these industries and then developing a time bound action plan in the medium to long term.

(d) Encouraging production of blended cement

As has been mentioned earlier, majority of the industrial processes emissions from Malaysian industrial sector come from the cement sector. Decreasing the share of clinker in cement by adding fly ash, slag etc. and producing blended cement allow reduction of process-related emissions. The use of fly ash and slag for clinker production is dependent upon the availability and use of coal in thermal power stations and steel making through the blast furnace route respectively. Since coal is likely to be used in relatively large proportions in thermal power stations to generate electricity in the future in Malaysia, fly ash obtained can be used for making Portland Pozzalona cement (PPC).

(e) Transformation of the Industrial Sector

The electrical & electronics (E&E) industry is the leading sector in Malaysia's industrial sector, contributing significantly to the country's manufacturing output (31%), exports (48.7%) and employment (33.7%). While Malaysia has built up significant clusters in E&E, much of the activity is in relatively low value-added assembly rather than higher value-added activities such as component manufacturing or R&D¹³⁴. There is a need to revitalise the E&E sector by focusing on sectors that are high-value and high-growth and in which it has existing strengths. The electronics and electrical sector has the potential to bring highly-skilled jobs and a deep scientific and technological base to Malaysia. The sector would play a key role in building a sustainable innovation-driven Malaysian economy in the future.

Table 3.11.4 categorises the above recommendations in various time periods as some of them require huge capital investment and gestation period to yield results.

Table 3.11.4: Categorisation of recommendations in various time periods

Short term	Medium term	Long term
Energy audits	Production of blended cements	Promote Cogeneration in industrial facilities
Capacity building	Transformation of the industrial sector towards higher value add activities	Cleaner technologies for SME's
Improved housekeeping	Replace inefficient electric motors	

Source: TERI Analysis

3.11.2.3 Recommendations for the Residential and Commercial Sectors

Programmes for both the sectors can be designed in a manner so that they facilitate planning and implementation of energy efficiency programmes at every level of the administrative set-up, i.e., at the national, state and local levels while simultaneously involving the community and other stakeholders.

¹³⁴ Economic Transformation Programme, A roadmap for Malaysia

The goal is to provide local authorities with resources needed to swiftly implement successful and sustainable clean energy programmes. The specific objectives include provision of proactive assistance, technical expertise, best practices, network expansion, and policy and programme development in order to accelerate implementation, improve programme and project performance, increase the return on investments, increase the sustainability of investments, and build protracted capacity at the national, state, and local levels.

Three essential pillars towards ensuring a stable energy efficiency programme are:

i. Building up the supply of auditors and contractors

- Involves identifying, recruiting, training, certifying, and mentoring participants

ii. Building up demand for energy services for the homeowners

- Educating homeowners about their energy use, about the programme, the processes,
- Advertise programmes through a variety of different marketing channels, radios, billboard, or community events.

iii. Developing a programmatic framework and provide quality assurance and quality control

- Providing the tools and trainings for contractors
- Taking into account the needs of contractors and other audiences for whom the tool is being developed
- Pertubuhan Akitek Malaysia (PAM) has developed a comprehensive action plan that details out steps needed to realize the targets and outcomes as mentioned in the Low Carbon Cities Framework document.

Action Point 1: Online resource library

An extensive online resource library with best practices, templates, events calendar, and other resources can be made available so as to ensure a wider outreach to all stakeholders. It is to facilitate as well a peer exchange of best practices and lessons learned. The topics could include energy efficiency and renewable energy technologies, programme design and implementation, financing, performance contracting, and state and local financing.

Action Point 2: Voluntary rewards programme for manufacturers

With regards to equipment labelling, a voluntary programme that rewards those project manufacturers that want to create more energy efficiency products would provide larger incentives until the labelling programme is made mandatory. What it really does is addressing a market imperfection, where without some sort of branding, there may be manufacturers that want to build more energy efficient products, but are reluctant to invest in improving their products because if they try to sell them in the market place, customers may not necessarily believe that their claims are true. Through this programme, brand reliability and trustworthiness will be ensured and simultaneously allow customers to make informed purchasing decisions.

Action Point 3: Redirecting and reducing subsidies

Improving residential energy efficiency helps households cope with the burden of paying utility bills and helps them afford adequate energy services. Reducing the economic burden of utility bills is an important co-benefit of energy efficiency for less affluent households.

In economies in transition such as Malaysia, this situation provides an opportunity to redirect social programmes which are aimed at compensating for increasing energy costs towards energy-efficiency efforts. With plans to reduce energy subsidies gradually from 2015 onwards, resource allocation towards energy-efficiency efforts will have a critical role.

Energy pricing that does not reflect the long-term marginal costs of energy, including direct subsidies to some customers, hinders the penetration of efficient technologies (Alam et al., 1998). However, the abrupt lifting of historically prevailing subsidies may also have adverse effects. Malaysia can follow a policy of gradual decrease in subsidies and an increase in electricity tariffs at regular intervals. An option that can be considered and one that was mentioned in discussions with representations from different government agencies such as the MEGTW, Energy Commission, MGTC and many others was the policy of “Consume more, Pay more”. According to this, for all households consuming more than 200 kWh per month will pay a differential tariff for the additional consumption of electricity. The bar of 200 kWh has been set as it has been estimated as the minimum energy requirement by a household. A social-safety net of sorts can be provided to low-income groups wherein the tariffs are subsidized.

Associated impacts of energy efficiency on Macroeconomic and Development Goals

In developing countries, energy-efficient household equipment and low-energy building design can contribute to poverty alleviation through minimizing energy expenditures, therefore making more energy services affordable for low-income households (Goldemberg, 2000). Clean and efficient utilization of locally available renewable energy sources reduces or replaces the need for energy and fuel purchases, increasing the access to energy services. Therefore, sustainable development strategies aimed at improving social welfare go hand-in-hand with energy efficiency and renewable energy development.

Additional co-benefits of building-level GHG mitigation include improved energy security and system reliability (IEA, 2004f). Improved end-use energy efficiency is likely to generate additional macro-economic benefits because reduced energy imports will improve the trade balances of importing countries.

Energy-efficiency investments will also have associated positive effects on employment, directly by creating new business opportunities and indirectly through the economic multiplier effects of spending the money saved on energy costs in other ways (Laitner et al., 1998; Jochem and Madlener, 2003).

Action Point 4: Minimum Energy Performance Standards (MEPS) and Energy Managers

Voluntary agreements, in which the government and manufacturers agree to a mutually acceptable level of energy use per product, are being used in place of, or in conjunction with, mandatory MEPS to improve the energy efficiency of appliances and equipment. Voluntary measures can cover equipment, building design and operation and public, and private sector energy management policies and practices. Examples include Green Lights in the EU and the Energy Star programmes in the USA, as well as successful EU actions for the reduction of standby losses and efficiency improvement of washing machines and cold appliances. The Energy Commission in Malaysia has already incorporated the MEPS into the proposed Energy Efficiency Act and if this is accepted, it will facilitate a policy environment for ensuring emission reductions in the commercial and residential sectors.

An important recommendation along with this is making it mandatory for all commercial establishments to employ an Energy Manager who would conduct regular audits and implement energy efficiency measures in their respective establishments. As mentioned earlier, it is important to incentivize and provide appropriate infrastructure to train Energy Managers.

Action Point 5: Energy Service Companies (ESCOs)

While not a 'policy instrument', ESCOs have become favoured vehicles to deliver energy-efficiency improvements. An ESCO is a company that offers energy services, such as energy analysis and audits, energy management, project design and implementation, maintenance and operation, monitoring and evaluation of savings, property/facility management, energy and/or equipment supply and provision of energy services (e.g., space heating, lighting). ESCOs guarantee the energy savings and/or the provision of a specified level of energy service at lower cost by taking responsibility for energy-efficiency investments or/and improved maintenance and operation of the facility. This is typically executed legally through an arrangement called 'energy performance contracting' (EPC). In many cases, the ESCO's compensation is directly tied to the energy savings achieved. ESCOs can also directly provide or arrange for project financing, or assist with financing by providing an energy (cost) savings guarantee for their projects. Finally, ESCOs often retain an ongoing operational role, provide training to on-site personnel, and take responsibility for measuring and verifying the savings over the term of the project loan. ESCOs greatly facilitate the access of building owners and operators to technical expertise and innovative project financing. They can play a central role in improving energy efficiency without burdening public budgets and regulatory intervention to markets. However, policies and initiatives may be necessary to kick-start the market for ESCOs. In some cases, obligations imposed on electricity companies have fostered the development of ESCO activities, as in the case of Brazil, where power utilities are required to invest 1% of their net operating revenues in energy efficiency. Thus, the setting up of ESCOs should be considered very seriously as an important policy option in Malaysia as it could serve as a key tool towards energy efficiency.

A significant barrier, especially in the commercial sector is that many energy-efficiency projects and ventures in the buildings sector are too small to attract the attention of investors and financial institutions. Small project size, coupled with disproportionately high transaction costs, prevent energy-efficiency investments. Small enterprises often receive higher returns on their investments into marketing or other business-related activities than investing their resources, including human resources, into energy-related activities. Conservative, asset-based lending practices of financial institutions, a limited understanding of energy-efficiency technologies on the part of both lenders and their consumers, lack of traditions in energy performance contracting, volatile prices for fuel (and in some markets, electricity), and small, non-diversified portfolios of energy projects all increase the perception of market and technology risk (Ostertag, 2003; Westling, 2003; Vine, 2005).

In summary, investments in residential and commercial building energy efficiency and renewable energy technologies can yield a wide spectrum of benefits well beyond the value of saved energy and reduced GHG emissions. Several climate mitigation studies focusing on the buildings sector maintain that, if co-benefits of the various mitigation options are included in the economic analysis, their economic attractiveness may increase considerably – along with their priority levels in the view of decision-makers (Jakob et al., 2002; Mirasgedis et al., 2004; Banfi et al., 2006). Strategic alliances with other policy fields, such as employment, competitiveness, health, environment, social welfare, poverty alleviation and energy security, can provide broader societal support for climate change mitigation goals and may improve the economics of climate mitigation efforts substantially through sharing the costs or enhancing the dividends (European Commission, 2005). In developing countries such as Malaysia, residential and commercial-sector energy efficiency and modern technologies to utilize locally available renewable energy forms, can form essential components of sustainable development strategies.

Suggested Roadmap

(a) Short Term

- i. Essential that more buildings get registered under the GBI and adopt more efficient technology for air-conditioning and lighting.
- ii. Energy managers must be registered for each commercial establishment so that each establishment's energy consumption is minimized over time.
- iii. To reduce the emissions from commercial sector the Malaysian government should make the voluntary programme under the standard MS 1525:2007-Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings mandatory for all the buildings.
- iv. Include more appliances under the current voluntary Equipment Labelling Programme
- v. Monetary incentives for residential sector to undertake energy efficiency measures.
- vi. Education of people with regard to efficient use of electricity is needed.
- vii. Technology evolution to be tracked by Energy Commission for regular revision of rating system.

(b) Medium Term

With the targeted GDP growth rate at 6% per annum by 2020, the GDP service is expected to grow quickly. Between 2000 and 2010, the GDP contribution of business services grew by 7.9% a year making it the second fastest growing sector in the economy. It has been proposed that Economic Transformation Programme (ETP) will result in Malaysia becoming a high-income nation with GNI per capita of RM 48000 by 2020 and services will account for over 65% of GDP. Thus, with the growing service sector, it is necessary that the energy consumption is efficient and sustainable in the long run.

- i. Continuation of the incentives currently provided to the GBI certified buildings is as follows:
 - Investment tax allowance.
 - Stamp duty exemption.
- ii. Reduction in electricity subsidies.
- iii. Preparation among consumers for an increase in tariffs – consumption habits need to be changed.
- iv. Strategy of “Consume more, Pay more” to be adopted.
 - Social safety net for low income households to be designed with a Lifeline Band of 200kWh.
 - Differential tariff based on electricity consumption.
- v. Need to decouple pricing from social welfare.
- vi. Introduction of MEPS so as to make equipment labelling mandatory.
- vii. Transformation of market needed through incentives for technology improvement.
- viii. Phasing out of incandescent bulbs and replacing with CFLs/LEDs and encourage domestic manufacturing of lighting appliances.

(c) Long Term

- i. Solar energy is the most promising backup energy as it has many advantages over other resources. Malaysia has a promising potential to establish large scale power installations due to its location and equatorial region; however, solar energy is still at the infancy stage due to high cost of photovoltaic (PV) cells and solar electricity tariff rate.
- ii. Decentralised energy systems to be considered.
- iii. LED and solar street lighting
 - Local companies being encouraged to manufacture.
 - Help bringing prices down.
 - Huge market exists for solar.
 - 55 cents per kWh for solar to be further looked into.
- iv. Efforts are required in research and development on solar energy to overcome the barriers to enhance the PV market. In the 9th Malaysia Plan (9MP), a large allocation had been dedicated for implementation of solar PV systems.
- v. Low Carbon City Framework to be implemented in collaboration with PAM and other stakeholders. The GBI Township tool has been prepared to facilitate the Low Carbon Cities Framework (LCCF) – while the LCCF is a policy document, the GBI Township tool is an action document for implementation.
- vi. Mandatory reporting in terms of energy efficiency/audits for both residential and commercial.

Achieving energy efficiency is a considerable challenge yet at the same time it is also a critical component in terms of climate change mitigation. Increasing trends in per capita energy consumption can have serious implications for the future. Thus, it is very important to understand some key issues in the residential and commercial sector which would set the motion for further analysis.

The current plan for Malaysia includes two key programmes, namely the Green Buildings Initiative and retrofitting of existing buildings into energy efficient buildings. Both need to be pursued aggressively to achieve the 40% emission reduction target.

The Green Buildings Initiative has relevance to both the commercial and residential sectors. It is necessary to understand the trends in growth of green buildings in the two sectors across Malaysia. The current initiative involves voluntary compliance. The new policy could include compulsory compliance to building standards.

It is not only important to have strong policies but it is also critical to ensure that the implementation and design of the policies are in tune with the local conditions and consumer choices.

3.11.2.4 Recommendations for Energy Supply Sector

Malaysia has always been a net exporter of energy with commercial energy supply of the country greater than the commercial energy use. However, resource augmentation and growth in energy supply has not kept pace with increasing demand and, self-sufficiency has been continuously declining. If this trend continues, there could be a potential scenario in which Malaysia may eventually become energy deficient. To avoid this situation, it is imperative to focus on increasing the supply of indigenous energy resources. Hence, Malaysia should plan to enhance efforts in R&D in the exploration and production of energy resources.

Combined cycle gas power plants account for the highest share of electricity generation as well as for generation capacity, followed by coal. Open cycle power plants are used for meeting peak demand. New gas turbine combined cycles for natural gas are employing E/F class technologies. The average efficiency of combined cycle power in Malaysia is very low at around 41-43%. However, new plants that are coming up have higher efficiency. In Malaysia, conventional steam cycle with sub-critical steam parameters technology is currently being used for coal based thermal power generation. The existing coal-based sub-critical steam cycle power plant technologies in Malaysia have reached the level of 35% generation efficiency. Moreover, the super-critical coal plant technology of efficiency 38% is currently being adopted for the new unit of coal plant.

In the world best combined cycle based power plant, efficiency up to 58%-60% has been achieved. Similarly, the efficiency of world best coal plants are: sub-critical (44%), super critical (46%), ultra super-critical (48-49%), IGCC (50%), world's best ultra-supercritical by 2020 (50-55%). Malaysia's power sector therefore needs to examine its options in terms of moving to more efficient coal and gas based technologies. However, the choice of technologies would need to be based on resource availability, costs, etc., and require a techno-economic analysis. Here, price of fuel would play an important role.

There is a huge potential of hydroelectricity in Sarawak, but most of the electricity demand is concentrated in Peninsular region. Therefore, electricity demand should be created in the Sarawak region particularly through industrial development.

The Malaysian RE policy and action plan also sets a target, it is proposed that by 2020, the RE capacity will reach 2,080 MW or approximately 11% of the total peak electricity demand capacity. Key recommendations for renewable energy sector are:

- i. Set up aggressive RE target for both grid and off-grids applications.
- ii. Assess the potential of decentralized RE systems across different potential sectors and creating appropriate policy and incentive structure.
- iii. Rationalize price of fossil fuel to provide level playing field for renewable energy development and
- iv. Create a manufacturing base of RE.

It is worthwhile to mention that also for the 8th and 9th Malaysian plan ambitious targets for RE were set up, however, the implementation of these were rather low. Therefore, success of achieving target set under RE policy and action plan is a big challenge. Furthermore, diffusion of RE depends on variety of factors ranging from site specific resource availability constraints to global market dynamics related issues. Therefore, a detailed and in-depth analysis would be required for assessment of a more realistic action plan for renewable energy.

3.12 Others Sector

As per NC2, the total energy sector emissions in 2005 were 204.3 MtCO₂ eq. This constitutes emissions from transport, industrial, residential, commercial, electricity generation and others sectors. While the emissions from transport, industrial, residential and commercial, and power sectors account for about 70% (142.5 MtCO₂ eq) of the total emissions from the energy sector, which has been validated through the bottom-up accounting in our study, the remaining 30% (61.8 MtCO₂ eq) is accounted for as “Others” within this study. NC2 gives the break-up of the “Others” sector in terms of energy industries which include; manufacture of solid fuel, petroleum refining and, fugitive emissions from fuels such as natural gas, oil, flaring, coal mining, etc.

Table 3.12.1: “Others” Sector as given in NC2 (MtCO₂ eq)

Sector	GHG Emissions (2005)
Fugitive emissions	27.1
Manufacturing of solid fuels and other energy industries	24.3
Oil refining	9.3
Difference of GHG emissions for energy sector estimated by reference and sectoral approach	1.1
TOTAL	61.8

Source: GHG Inventory for Energy sector and Industrial Processes for NC2, 2009, by PTM

The total emissions of the “Others” sector added up to 61.80 MtCO₂ eq. in 2005 (Table 3.12.1). However, the “Others” sector includes all the elements that have not been quantified and validated in our exercise. Therefore, the “Others” are not detailed out in terms of options and reduction potential.

Nonetheless, for accounting purposes, the share of the emissions from the “Others” sector to the total emissions from energy sector in 2005 has been calculated. This share has also been assumed to be constant for all years ahead including 2020 and 2030.

Potential Mitigation Options

Fugitive Emissions

Fugitive emissions from fossil fuels are intentional or unintentional releases of greenhouse gases (GHGs) from the production, processing, transmission, storage, and delivery of fossil fuels mainly from the oil and natural gas sectors and the coal mining sector. Within these two sectors, emissions from methane form the largest contribution to the greenhouse gas emissions.

Some of the measures to reduce GHG fugitive emissions in the fuels sector include:

- i. recovery of methane emissions from coal mining through degasification;
- ii. enhanced degasification or oxidation of ventilation air methane; and
- iii. the reduction of methane emissions from chronic leaks, and reduction of emission from venting and flaring.

Table 3.12.2: Possible mitigation options for reducing fugitive emissions from coal mining, flaring and oil and natural gas extraction

Sector	Name
Coal mining	- Enhanced degasification - Degasification - Oxidation of ventilation air methane
Oil and Natural Gas	- Chronic leaks (pipelines, distribution facilities) for both oil and natural gas - Reducing flaring emissions - Elimination of venting

3.13 Conclusion: Malaysia's Mitigation Roadmap

This section brings together and presents the overall mitigation analysis across all sectors and provides a comprehensive understanding of emission levels in the Malaysian economy as a whole and for each of the sectors across the BAU and AMB scenarios. Further, we provide a roadmap for the economy indicating the priority areas for Malaysia, to help in making appropriate choices and decisions within and across sectors.

Table 3.13.1 presents the likely GHG emissions under the BAU and the AMB scenario for 2020 and 2030 across each sector. Due to variation in the method used in IPCC reporting pattern and the pattern used in the NC2, the total emissions are presented using three approaches (i) without LULUCF (Case 1), (ii) with LULUCF (Case 2) and (iii) with emissions from LULUCF but not sink (Case 3).

Table 3.13.1: GHG emissions projection (MtCO₂ eq.)

Sector	2005	2020		2030	
		BAU	AMB	BAU	AMB
Energy					
Electricity	57.5	85.6	71.7	136.2	97.4
Transport	45.3	88.7	70.5	125.3	80.5
Industrial	35.5	35.5	31.5	49.2	40.9
Residential & Commercial	4.3	9.2	8.1	18	12.3
Others*	61.8	95.0	78.8	142.5	100.2
Total Energy	204.4	314.0	260.63	471.20	331.30
Industrial processes	15.6	22.3	21.4	33.8	30.2
Agriculture	6.6	7.2	5.8	8.3	6.7
Waste	27.4	46.6	14.7	57.3	17.7
LULUCF emissions	25.3	32.7	26.1	28.0	22.4
LULUCF net emissions (source – sink)	-215.2	-399.1	-405.7	-380.7	-386.6
Total without LULUCF (Case 1)	253.9	390.08	302.45	570.64	385.89
Total with LULUCF (Case 2)	38.7	-9.06	-103.22	189.68	-0.68
Total with emission from LULUCF but not sink (Case 3)	279.2	422.74	328.48	598.68	408.32
GDP (RM million)	449,250	961,214	961,214	1,463,191	1,463,191
Emission Intensity (kg CO ₂ /RM) without LULUCF (Case 1)	0.565	0.406	0.315	0.390	0.264
Emission Intensity (kg CO ₂ /RM) with LULUCF (Case 2)	0.086	(0.009)	(0.107)	0.130	(0.001)
Emission Intensity (kg CO ₂ /RM) with Emissions from LULUCF but not sink (Case 3)	0.621	0.440	0.340	0.409	0.279

table continues...

Sector	2005	2020		2030	
		BAU	AMB	BAU	AMB
Reduction in Emission Intensity from 2005 level without LULUCF (%) (Case 1)		28%	44%	31%	53%
Reduction in Emission Intensity from 2005 level with LULUCF (%) (Case 2)		111%	225%	(50%)	101%
Reduction in Emission Intensity from 2005 level with emission from LULUCF but not sink (%) (Case 3)		29%	45%	34%	55%

*Others include emissions from Energy industries such as fugitive emissions, manufacture of solid fuel, petroleum refining, etc.

Note: GHG emission projection based on NC2 reporting is shown in Appendix 3.1. The results show marginal difference of 1% for AMB scenario (2020 at 47% reduction, & 2030 at 59% reduction)

As indicated in Table 3.13.1, Malaysia's emissions intensity of GDP was 0.565 kg CO₂ eq/RM, 0.086 kg CO₂ eq/RM and 0.621 kg CO₂ eq/RM in 2005, without LULUCF (Case 1), with LULUCF (Case 2) and with emissions from LULUCF but not sink (Case 3) respectively. Malaysia's voluntary target of reducing GHG emissions intensity of GDP up to 40% of 2005 levels by 2020, translates to a reduced emissions intensity of 0.406 kg of CO₂ eq/RM if LULUCF sector is not considered and (0.009) kg CO₂ eq/RM with LULUCF and 0.440 kg of CO₂ eq with emissions from LULUCF but not sink in 2020. In absolute terms, this implies that total GHG emissions would have to be limited to around 390.08 MtCO₂ eq., (9.06) MtCO₂ eq., and 422.74 MtCO₂ eq. in 2020 for Case 1, Case 2 and Case 3 respectively as compared to the respective levels of 253.9 MtCO₂ eq., 38.7 MtCO₂ eq. and 279.2 MtCO₂ eq. in 2005.

An analysis of the mitigation potential across all the sectors indicates that GHG emissions without LULUCF sector, under the BAU scenario would increase from 253.9 MtCO₂ eq. in 2005 to 390.08 MtCO₂ eq. in 2020 and 570.64 MtCO₂ eq. in 2030. In the AMB scenario, the emissions would increase to 302.45 MtCO₂ eq. and 385.89 MtCO₂ eq. in 2020 and 2030 respectively (Case 1). Consequently, in the BAU scenario, emission intensity of GDP would reduce by 28% in 2020 and by 31% in 2030 from 2005 levels without considering LULUCF (Case 1). Accordingly, with current efforts and existing plans and policies, Malaysia would be unable to meet its commitment of 40% emission intensity of GDP reduction by 2020.

In the AMB scenario, emission intensity of GDP reduce by 44% in 2020 and by 53% in 2030 from 2005 levels without considering LULUCF (Case 1). This indicates that if efforts were made across all sectors in line with those considered in the AMB scenario, the commitment of 40% emission intensity reduction is achievable by 2020 itself and beyond.

When reduction in emission intensity of GDP is considered with LULUCF, in the BAU scenario, emission intensity decreases from 2005 levels by 111% in 2020 and increases by 50% in 2030. In the AMB scenario, however, the emissions intensity decreases from 2005 levels by 225% in 2020 and 101% in 2030 respectively.

For the Case 3 where emission from LULUCF are accounted but sink is not included in the BAU scenario, emission intensity decreases from 2005 levels by 29% in 2020 and 34% in 2030 respectively. In the AMB scenario, the emission intensity decreases from 2005 levels by 45% in 2020 and 55% in 2030 respectively.

From the viewpoint of negotiations and the country's response to the Copenhagen accord, it is important for Malaysia to consider how it would like to interpret the voluntary reduction in terms of considering the inclusion of the LULUCF sector, both at the base year level and beyond. In this study, the analysis for all three cases was conducted (without, with LULUCF sector and with emission from LULUCF and not sink), and highlighted as an important consideration for the government to further deliberate upon.

This study considers socio economic development to progress in line with government expectations (reflected by population and GDP trajectories provided by Malaysian government). However, in reality, variation in these parameters can have major implications on the overall development and structure of the economy as also the implications on overall emissions. While it is beyond the scope of this study to examine the effect of such structural changes, given that GDP is an important factor that has a bearing on the success in achieving the voluntary mitigation target, a sensitivity analysis for changes in GDP was conducted.

Assuming a GDP growth rate of 4.2% per annum till 2030 indicative of the economic growth patterns projected from existing sources of data provided by the stakeholders, emission intensity reduces by 17% and 20% in the BAU scenario by 2020 and 2030 respectively, without considering LULUCF. In the AMB scenario, the emission intensity reduces by 36% and 46% by 2020 and 2030 respectively, without considering LULUCF. Comparatively, in the case of with LULUCF, the emission intensity decreases by 66% and increases by 89% by 2020 and 2030 respectively in the BAU scenario. In the AMB scenario, the emission intensity reduces by 190% and 83% by 2020 and 2030 respectively, inclusive of LULUCF.

Table 3.13.2: Sensitivity analysis with increase in GDP growth rate

Scenario	2005	2020		2030	
		BAU	AMB	BAU	AMB
With 4.2% GDP Growth GDP (RM million)	449,250	832,729	832,729	1,256,554	1,256,554
Reduction in Emission Intensity from 2005 level without LULUCF (%) (Case 1)		17%	36%	20%	46%
Reduction in Emission Intensity from 2005 level with LULUCF (%) (Case 2)		66%	190%	(89%)	83%
Reduction in Emission Intensity from 2005 level with emission from LULUCF but not sink (Case 3)		16%	33%	21%	45%

Source: TERI Analysis, 2012

With a 4.2% growth rate of GDP in the without LULUCF case, the 40% emission intensity reduction target cannot be achieved by 2020 but will be achieved by 2030 in the AMB scenario. In the BAU scenario, the emission intensity reduction is not achievable either in 2020 or in 2030 with 4.2% GDP growth. The sensitivity analysis clearly indicates that while it is important for Malaysia to try and achieve emission reduction / increase sinks to around the levels as suggested in the AMB scenario presented in this report, it is equally important for the country to ensure that a high level GDP growth rate can be maintained over the next decade and beyond. There is, therefore, a need to prioritize and focus on activities and areas that could bring in high value added growth across sectors.

The end use sectors including residential, commercial and industrial sectors have several opportunities for reaping the benefits from low hanging fruits. Significant savings are possible in the residential sector by increasing awareness regarding monetary savings from simple measures involving the use of efficient appliances and behavioural changes, such as switching off lights when not in use. Similarly, the industrial sector offers the opportunity for saving energy and increasing profitability across several enterprises simply by better operating procedures and simple house-keeping measures. Towards this end, undertaking energy audits across various industrial sub sectors and putting together databases to compare energy intensity norms across various units can facilitate progressive improvement in energy efficiency across the sector.

To sum up, our analysis indicates that Malaysia has ample opportunities across various sectors to meet its voluntary commitment of 40% emission intensity reduction. However, while it is commendable that the Malaysian government has taken on an

ambitious voluntary target for emissions reduction, the country at the same time needs to holistically evaluate its development path and options that it would like to consider from various perspectives – be they in terms of employment opportunities, larger welfare considerations at the household level, choices regarding self-sufficiency in food and energy resources, evaluation risks and benefits associated with the use of alternative fuel and technology choices, changes in patterns of trade or considerations related to natural resources and ecological services. Accordingly, while there may be theoretically large possibilities in some sectors (as considered in our analysis so far), there are a number of considerations that would limit the actual up-take of the level of options (including cultural, social, political and economic considerations).

Further, some sectors offer relatively small potential for emission reduction, while others can bring in huge benefits. The level of efforts and allocation of funds should, therefore, be judiciously allocated to the key areas that can help Malaysia realize its mitigation target.

Planning and prioritizing efforts towards mitigation also need to be evaluated in terms of their timeliness. There exist several “win-win” opportunities or “low hanging fruits” especially on the energy demand side wherein simple measures could be adopted to increase awareness, set up norms, undertake audits, etc. to provide a facilitative environment for efficiency improvement across sectors. On the other hand, solutions that involve changing supply side technologies or using alternative fuels involve a significant gestation period and a switch towards such options should necessarily be preceded by adequate due diligence, investment of time and resources in R&D and skill enhancement, and in setting up of appropriate supportive policy and regulatory changes. Accordingly, the roadmap for 40% emission intensity reduction in Malaysia needs to consider the various recommendations in a phased manner (short/ medium/long term) as discussed in the earlier sections and with varying levels of prioritization and urgency as indicated in Figure 3.13.1.

Figure 3.13.1 provides a schematic representation of the proposed roadmap for Malaysia across various sectors, based on a qualitative prioritisation of various actionable areas considering various factors affecting the options. The prioritization tries to keep under consideration the goals of economic growth and development that Malaysia has as part of its Economic Transformation Programme and our understanding of the status of R&D, technology, finance and institutional capacities across each of the sectors.

Actions in each of the sectors have been categorized across four areas for representing a snapshot vision of the suggested roadmap:

- i. Research, Development and Innovation.
- ii. Technology Development.
- iii. Finance and Investment.
- iv. Institutions.

Research, Development and Innovation	Short Term	Medium Term	Long Term
Power Sector	●	•	•
Transport	○	○	○
Industrial	○	○	○
Residential and Commercial	○	○	○
Agriculture	○	•	•
Waste	●	•	○
Forestry	○	○	○
Technology Development	Short Term	Medium Term	Long Term
Power Sector	•	●	●
Transport	○	•	●
Industrial	○	○	○
Residential and Commercial	○	○	○
Agriculture	○	•	•
Waste	○	○	○
Forestry	○	○	○
Finance and Investment	Short Term	Medium Term	Long Term
Power Sector	○	●	●
Transport	●	●	●
Industrial	○	○	○
Residential and Commercial	○	○	○
Agriculture	○	•	•
Waste	●	●	○
Forestry	○	•	●

table continues...

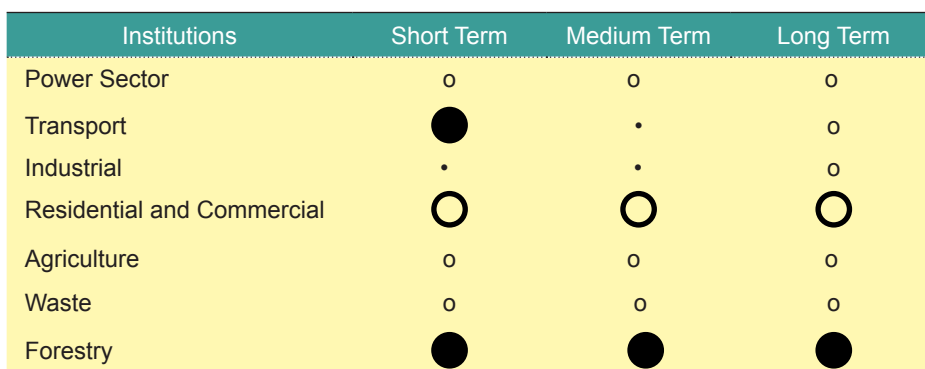


Figure 3.13.1: Schematic representation of the proposed roadmap for Malaysia

Note: Size of circle represents relative importance; White circle indicates relative ease in achieving the action while Black circle indicates that significant efforts need to be taken ; short term (2013-2015), medium term (2016-2020), long term (beyond 2020)

Accordingly, as represented in Figure 3.13.1, focus on R&D and innovation needs to be made in the power and waste sectors with a sense of urgency and importance. Innovative measures need to be undertaken in the residential and commercial as well as LULUCF sectors to tap available and known mitigation options to bring in the benefits quickly. Transport sector options while available, would need to be incorporated into the Malaysian economy over a period of time.

With regard to technology development, the power and transport sectors need to make deliberated efforts in the medium to long term to bring in technologies most suited to the Malaysian context. The power sector should focus on R&D and technology change as power demands would continue to increase rapidly. Changes to super-critical rather than subcritical coal based technologies in the power sector can be brought in even in the short and medium term, while the share of zero carbon options would need to be increased in the longer term. In the transport sector as well, given the need to decrease dependence on petroleum fuels, technology development to enhance the use of electricity based on renewables and other alternative fuels is suggested. Several available options for efficiency improvement exist even in the short term in the residential / commercial and industrial sectors that can be easily provided in the short to medium term. Suitable technology options in the waste sector are also well known and should be brought in by the medium to long term.

With regard to finance and investment needs, the power and transport sector needs the largest focus in the medium to long term. As indicated in the results, additional investment requirements are likely to be highest in the power sector, especially if alternative fuel and technology options such as nuclear and renewables are adopted. In case of transport, while the model does not consider the investment cost of related infrastructure development for increase in rail based movement and public transport (and consequently, indicating lower investment costs in the ambitious scenario), it is important to note that both public transport and increase in rail based movement would entail significant investment to be incurred on part of the government (public spending) rather than personal expenditure on part of consumers as in case of personalised transportation modes.

Investment needs are also expected to be high in the waste sector and need to be carefully planned in the short to medium term. In case of LULUCF, while some immediate short term measures can be undertaken without much investment, in the long term, the sector is the most important for Malaysia's mitigation target and would require adequate investments to be planned for.

In terms of institutions and policy changes, Malaysia already has several policies in the right direction which need to be strengthened and their adoption / implementation facilitated. The transport sector in particular, has a large need for focusing on the policy and institutional side as is the case with other demand side sectors such as the residential and commercial sectors.

Focus on finance and investment is also seen as an important priority in the power sector.

In the transport sector, while R&D is not seen as an immediate and high priority area, there is a large opportunity to bring about technological change (modal shifts) in the medium to long term. High priority needs to be accorded to directing investment towards enhancing public transport and introducing legislation frameworks that facilitate greater efficiency.

In the industrial sector, several technologies are available for enabling emission reductions in an easy and cost-effective manner. While research and development is essential in the long run, a little effort with respect to investment and technology development will go a long way in improving the performance of the industrial sector. It will be essential for the institutional set-up to be strengthened such that the sector is at par with global standards.

The residential and commercial sectors present sufficiently large potential for emissions reduction and should be considered a priority sector. R&D activities linked to this sector need to focus on the use of renewable energy, particularly solar, that could be taken up even in the short term. Most technology changes in these sectors would not require large investments and it should be considerably easy to improve the overall energy use intensity in this sector. Institutions, however, need to play an important role in ensuring that the right kind of policy environment is created to enable the technology changes.

In the agriculture sector, research and development activities along with technology development are important in the medium and long term to improve practices such as livestock management and manure management. Overall, the sector however does not call for a very high priority being accorded to investment or institutional capacity building, etc.

The waste sector has a considerably large potential for emissions reductions. With appropriate efforts being directed towards mobilizing investments towards scaling up recycling and immediate attention being paid to innovative models for addressing emissions from waste, this sector can provide considerable benefits.

The forestry sector is very critical to the Malaysian economy as it can serve as a large sink for carbon capture and sequestration. Focus on institutions and investment will be critical to the protection and management of existing forests in Malaysia, and in achieving the required emission intensity reduction.

CHAPTER 4: DEVELOPMENT OF TECHNOLOGICAL INTERVENTIONS TOWARDS LOW-CARBON ECONOMY PATHWAYS

4.1 Introduction

Background

Climate change, a global issue exerting heavy influences on the whole world, has been attracting more and more attention because of its key role towards sustainable development. The international community including developing countries are taking unremitting efforts to this end on greenhouse gas (GHG) emissions reduction through the development of low carbon economy pathways.

Low carbon development not only becomes a social economic development pathway for Malaysia's future, but also facilitates Malaysia's economic restructuring and accelerates the growth of industries with high value add and low energy consumption. Malaysia is embarking on its strategic plan for increasing the domestic demand, promoting economic growth and cultivating a new economic pathway towards low carbon, and expedite development of its industry, constructions, transportation and energy sectors. To make progress in low carbon development, more efforts are required to reduce GHG emissions under the current social, economic, technological and resource conditions. The task ahead is challenging, but it also provides incentives and opportunities for the stakeholders. It can be achieved only through the implementation of various kinds of policies and measures comprehensively as shown in Figure 4.1.1 based on the study by Liu, Jiang & Hu (2011).

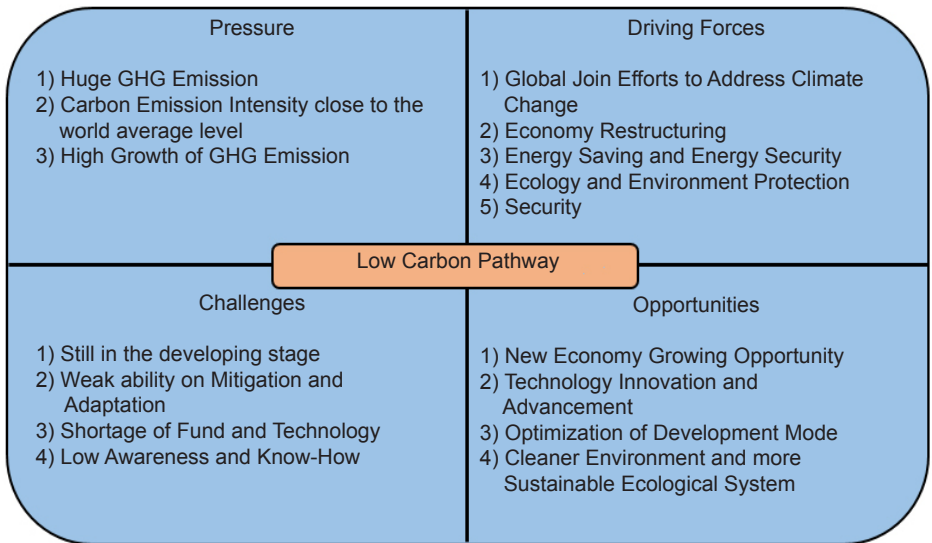


Figure 4.1.1: Four aspects of low carbon economy
Source: Liu, Jiang & Hu (2011)

Understanding Low Carbon Development

Low carbon development and low-carbon economy (LCE) are now widely used concepts around the world. LCE is a concept that refers to an economy which has minimal output of greenhouse gas (GHG) emissions into the biosphere, but specifically refers to greenhouse gas of carbon dioxide. LCE aims to integrate all aspects of socio-economic activities such as manufacturing, agriculture, transportation, and power generation around technologies that produce energy and materials that have minimal output of GHGs.¹³⁵

Green Growth can be defined as one of the implementing strategies to achieve sustainable development that focuses on improving ecological efficiency as a means to greening the whole economic systems and promoting a green economy, where economic prosperity can go hand-in-hand with ecological sustainability.

These LCE pathways demonstrate high energy efficiency, power themselves with renewable sources of energy, produce the lowest quantity of pollution possible, use land efficiency, compost used materials, recycle or convert waste to energy.

Brief descriptions of the sections in this chapter are as follows:

Section 4.2 focuses on Technology Needs Assessment with emphasis on the potentials of technological options applicable to the Malaysia economy.

Section 4.3 summarises the low-carbon economy development of selected countries. The literature review provides a benchmark for low-carbon economy pathway for Malaysia.

Section 4.4 presents the recommended technological interventions toward low-carbon economy pathways. The initiatives are segregated by sectors and recommendations for short term, medium-term and long-term in order to achieve low carbon economy.

Section 4.5 identifies the priorities for low-carbon investment by looking at the average GHG cost abatement cost for each of the sectors and potential mitigation options.

Section 4.6 presents the conclusion and way forward of the section.

¹³⁵ Janet L. Sawin and William R. Moomaw (2009) Renewable Revolution: Low-Carbon Energy by 2030 Worldwatch Report, 2009.

4.2 Technology Needs Assessment (TNA)

4.2.1 Purpose of Technology Need Assessment

The purpose of Technology Needs Assessment (TNA) Report is to evaluate and select priority greenhouse gas mitigation technological options. Technology needs assessment is a first step in technology transfer framework, which also includes technology information, enabling environment, capacity building and mechanisms for technology transfer. Developing countries such as Malaysia are vulnerable to the impacts of climate change but lacking in capacity to adapt to it. Development and transfer of adaptation technologies are relatively slow.

At present, there is lack of sub-regional climate model such as for Southeast Asian region for mitigation and adaptation studies. This results in high uncertainties for the analysis of climate change impact and hence its mitigation and adaptation needs. The limitation of technology know-how in research and development has compounded the uncertainty towards mitigation and adaptation policy analysis. Climate change initiatives from IPCC have proposed some approaches on how technologies for mitigation and adaptation towards the impact of climate change can be materialized. The proposed approach covers the steps of assessing technology needs, the process of transfer and the evaluation of the technologies. Appendix 4.1 explains on the approaches and methodologies for Technology Needs Assessment (TNA) as proposed by UNDP/GEF (2003).

The sectors that have been identified to be analyzed in terms of TNA are as follows:

- i. Power Sector
- ii. Transport Sector
- iii. Residential and Commercial Sector
- iv. Industrial Sector and Industrial Processes
- v. Waste Sector
- vi. Land Use, Land Use Change and Forestry (LULUCF) Sector
- vii. Agriculture Sector

4.2.2 Selection Criteria for TNA

Technology transfer priorities are selected using determined general and specific criteria. The general criteria are based on national-wide interest and priorities, while specific criteria reflects the priorities, current policies, objectives and situation of the energy sector.

(A) General Criteria

In accordance with national interests and policies, based on discussions with numerous stakeholders, five general criteria for the purpose of TNA were identified as follows:

Table 4.2.1: General criteria for technology selection

General Criteria	General Sub-Criteria
a. Conformity with national regulation and policy	• Food security (FS) • Natural resource security (NR) • Energy security (ES) • Incentives for participation (IP)
b. Institutional and human development	• Capacity building (production, know how, O&M) (CB)
c. Technology effectiveness	• Reliability of technology (RT) • Easiness of wider use of technology, including local contribution support of technology application (ET)
d. Environmental effectiveness	• Greenhouse gas emission reduction (GR) • Improvement of local environmental quality (LE)
e. Economic efficiency and cost effectiveness	• Capital and operational costs relative to alternatives (COC) • Commercial availability (market) (CA)

Source: UNFCCC, 2006

4.2.3 Preliminary Findings

The preliminary findings on the Technology Needs for each of the sectors are presented as follows:

4.2.3.1 Power Sector

Specific Criteria for Technology Selection

The four specific criteria and ten sub-criteria for technology transfer in the power sector are as follows:

Table 4.2.2: Specific Criteria for Technology Selection in Power Sector

Specific Criteria	Sub-Criteria
a. Consistency with national policies, targets and specific local situation	• Relevant to existing energy policy & target • Optimal utilization of local energy resources • Efficient utilization of energy resources
b. Economics and cost-effectiveness of technology	• Total capital cost • Internal Rate of Return • Payback period • Abatement cost
c. Technology development	• Advance but proven technology • Possibility for local manufacturing & production
d. Social acceptability	• Contribution towards socio-economic development

Technology Options Review

The main source of GHG emissions from the energy sector is generated by the activities in mining, processing, transporting, combusting of fossil fuels; combustion of fossil fuels to produce electricity, heat and transmission and distribution of electricity. Energy is produced to supply demand; in normal circumstances, more demand will lead to more supply unless there is supply disruption.

Given the situation of energy supply and demand, national targets, policy objectives and current programs in Malaysia, GHG emissions mitigation measures on the supply side can be achieved through several approaches:

- i. Deploying advanced thermal power technologies/clean coal technology to generate electricity.
- ii. Reducing carbon-based fuel combustion through three activities:
 - Switching from conventional fuels to alternative, non-carbon or fuel with less carbon content,
 - Increasing combustion efficiency,
 - De-carbonization of fuels and flue-gas.
- iii. Utilizing carbon storage and sequestration technology to reduce CO₂ emitted by power generation, oil and gas operations (e.g.: Carbon Capture and Storage).
- iv. Improving efficiency and reducing leakage in extracting, processing and transporting of fossil fuels and electricity.

Three areas of potential for GHG emissions mitigation in the power sectors are: electric power generation, renewable energy systems, co-generation and nuclear power.

(A) Electric Power Generation

The GHG mitigation options in the electric power generation are the use of more efficient power generation technologies for fossil fuels and the use of non-fossil fuels with lesser or no carbon content (nuclear and renewable, such as geothermal, hydro, mini hydro, pump storage, photovoltaic, wind, and waste derived fuels).

i. Clean Coal Technologies

The application of clean coal technologies (CCTs) in energy systems is one of GHG emissions mitigation options. The IEA (2008) has identified groups of CCTs which have the capability to reduce CO₂ emission from coal-fired power plants.

Coal upgrading technology: Coal upgrading technologies remove moisture from low-rank coals using various methods such as: direct heat (e.g. saturated steam drying), indirect heat (waste heat utilization or exhaust gas re-circulation) and electromagnetic energy. The dried coal is then briquetted as fuel for the power plant. The environmental effects of using upgraded coal are to reduce sulfur and mercury associated with water removal, increase heat content of coal, resulting in lower NO_x per energy generated and increasing fuel and boiler efficiency leading to lower CO₂ per energy generated. It is estimated that coal washing/drying and briquetting could reduce CO₂ emission by as much as 5%. This involves the application of established commercial technologies which are in use in the USA, Europe, Japan and Australia, but not yet widely deployed in the developing world or the former Soviet Union (IEA, 2008).

ii. Super Critical and Ultra Supercritical Power Plant

Efficiency improvements in existing plants: Conventional sub-critical plants can achieve thermal efficiency of up to 40%. Improving less efficient plants will reduce emissions. Supercritical and ultra supercritical plants can achieve efficiency of up to 45%, and are operating in Japan, USA, Europe, Russia, China and Australia. That level of efficiency can reduce CO₂ emissions by as much as 22%¹³⁶.

The advanced power generation technologies such as subcritical pulverized coal (SubPC), supercritical pulverized coal (SPC) and ultra supercritical pulverized coal (USPC), will increase efficiency, reduce fuel consumption and associated environmental pollution, and increase fuel diversity.

- Ultra Supercritical Pulverized Coal (USPC) power plant efficiency ranges from 44% to 46% with bituminous coal. A 500 MW USPC requires 164,000 kg coal per hour and emits 738 gCO₂ per kWh. Total plant costs RM 4,300 per KWe¹³⁷.
- The Supercritical Pulverized Coal (SPC) power plant has higher thermal efficiency compared to the conventional pulverized coal power plant. The efficiency for this type of power generation plant ranges from 37% to 40%, depending on coal quality, operations and design parameters. A 500 MW SPC requires 185,000 kg coal per hour and emits 830 gCO₂ per kWh. Total plant costs RM 4,200 per KWe¹³⁸.
- Subcritical Pulverized Coal (SubPC) technology has power generation efficiency of 33% to 37%, depending on coal quality, operation and design parameters. A 500 MW SubPC requires 208,000 kg coal per hour and emits 931 gCO₂ per kWh. Total plant costs RM 4,100 per KWe¹³⁹.
- Subcritical Fluid Bed Combustion (SFBC) is the technology suited to low cost waste fuels and low quality or low heating coal. A 500 MW SFBC power plant efficiency ranges from 34 to 35% with lignite. A 500 MW USPC requires 297,000 kg coal per hour and emits 1030 gCO₂ per kWh. Total plant costs RM 4,200 per KWe¹⁴⁰.

¹³⁶ TNA Synthesis Report for Indonesia, 2010

¹³⁷ Ibid.

¹³⁸ Ibid.

¹³⁹ Ibid

¹⁴⁰ Ibid.

iii. Integrated Gasification Combined Cycles

Integrated Gasification Combined Cycles (IGCC) technology produces electricity by first gasifying coal to produce syngas which, after clean-up, is burned in gas turbines which drive generators. The overall generation efficiency of IGCC is about 36 to 40.5 %, but the type of coal and gasifier will affect the efficiency. IGCC emits 102 gCO₂ per kWh. The investment cost for IGCC plant without CO₂ capture varies from RM 3,600 – RM 4,300 per kWe and RM 5,100 – RM 5,800 per kWe for IGCC with CO₂ capture.¹⁴¹

iv. Fuel Cell

The fuel cell power systems are characterized by high thermodynamic efficiency and low levels of pollutant emissions. Almost all the fuel cell technologies currently are developed for commercialization, by using pure hydrogen as the fuel, but they are not recommended for GHG mitigation option because the abatement cost is very high - similar to photovoltaic and wind power plants. The investment cost is estimated to be around RM 18 Billion over the five years period.

(B) Renewable Energy Technologies

Hydro and geothermal power have big potential in terms of available resources, giving the country a wide range of options for GHG emission mitigation from the power sector, if those resources are developed extensively in the near future.

Several types of new renewable energy technologies are still relatively expensive and cannot compete with current conventional energy technologies, dominated by fossil fuel technology, because although renewable energy releases less CO₂, it is still on a small scale, the investment cost is still relatively high and the utilization may not be cost-effective. Currently new renewable energy technologies are mostly used to generate electricity. Available renewable technologies for GHG emission mitigation are as follows:

i. Biomass

Biopower or biomass power is the generation of electric power from biomass resources. Biopower reduces most emissions (including GHG emissions) compared with fossil fuel-based electricity generation. Because biomass absorbs CO₂ as it grows, the entire biopower cycle of growing, converting to electricity, and re-growing biomass can result in very low CO₂ emission, compared to power generation from fossil fuels without carbon sequestration, such as coal, oil or natural gas. Through the use of residues, biopower systems can even represent a net sink for GHG emissions, by avoiding methane emission that would result from landfill of the unused biomass. Recent technologies for power generation from biomass are:

¹⁴¹ TNA Synthesis Report for Indonesia, 2010.

- a. Direct combustion of biomass (wood, bagasse) in a boiler and use of the heat generated to produce steam in a waste heat boiler. The steam is then used to drive a steam turbine connected to a generator. Biomass utilization, to produce heat and power, can avoid the use of fossil fuels. Plant efficiency is around 20% – 40%. Avoided emissions are based on the baseline. Typical capital cost is RM 6,300 – RM 9,900 per kW¹⁴². The diagram of the Direct Combustion and electricity generation is shown in Figure 4.2.1.

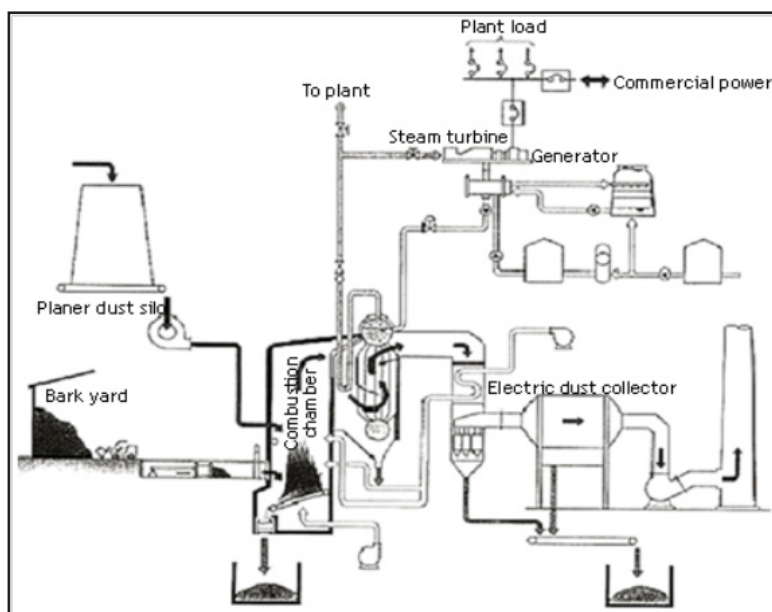


Figure 4.2.1: Direct Combustion and Electricity Generation Flow

- b. Co-firing: substitution of biomass with coal or other fossil fuels in existing boilers. Plant efficiency is about 35%, and co-firing of 15% biomass to substitute coal will give 23% GHG emission reductions. Typical capital cost for biomass/coal co-fired power plant is RM290 – RM 750 per kW plus power station cost¹⁴³.

Biomass gasifier: Biomass integrated gasification gas turbines (BIG/GT) are not yet in commercial use, but their economies are expected to improve. Recent technology has 30% – 40 % plant efficiency. Integrated Gasification Combine Cycles (IGCC) is already economically competitive in the CHP mode, using black liquor from pulp and paper industry as feedstock. . The efficiency is 30 – 40 % with total capital cost RM 8,000 – RM 16,000 per kW¹⁴⁴.

¹⁴² TNA Synthesis Report for Indonesia, 2010.

¹⁴³ Ibid.

¹⁴⁴ Ibid.

ii. Geothermal

Geothermal energy is heat from inside the Earth. Hot water or steam is used to produce electricity or applied directly for space heating and industrial processes. This energy can offset the emission of carbon dioxide from conventional fossil-powered electricity generation (usually coal fired power plant), industrial processes, building thermal systems, and other applications. Beside direct use of heat without converting to electricity, geothermal is being used to produce electricity. There are three technologies for electricity generation from geothermal energy sources:

- a. Binary Cycle technology: It is used for hydrothermal sources containing fluids with moderate temperatures (below 200°C). Binary Cycle system is used to extract their heat. The hot water and a secondary (hence, “binary”) fluid, with a much lower boiling point than water passing through a heat exchanger. Heat from the geothermal fluid causes the secondary fluid to flash to steam, which then drives the turbines. Because this is a closed-loop system, virtually nothing is emitted to the ground or the atmosphere. Binary Cycle has 93% capacity factor, with total capital cost RM 5,100 – RM 5,400 per kW_e for high quality resource¹⁴⁵. The schematic diagram is shown in Figure 4.2.2 below.

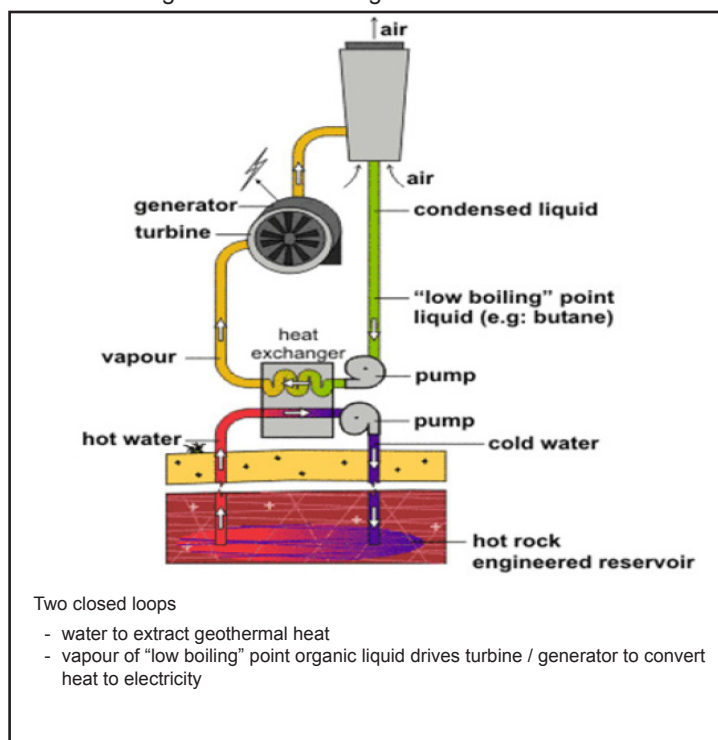


Figure 4.2.2: Schematic diagram of binary geothermal power Plant
Source: lgc.org (September 2011)

¹⁴⁵ TNA Synthesis Report for Indonesia, 2010.

- b. Flash Steam power plant: It uses hydrothermal fluids with temperatures above 200°C (400°F). The fluid is sprayed into a tank held at a lower pressure than the fluid, causing some of it to rapidly vaporize, or “flash” into steam. The steam drives a turbine, which then drives a generator. It has 93% capacity factor, with total capital cost RM 4,000 – RM 4,200 per kWe for high quality resource¹⁴⁶.
- c. Hot Dry Rock (HDR) technology: The heat from the earth, which uses the natural geothermal systems, is used in places where cracks or pore spaces are present. The major aspect of the successful heat mining is to form an engineered geothermal reservoir in a hot body that is an impervious rock. The surface in a hot rock body where an HDR reservoir is developed is determined by selecting a location on the surface where the injection well is drilled. It is also determined by the deepness within the well bore at which the water is pumped into the hot rock and converted into steam to generate carbon-free electricity, by the use of a conventional steam turbine technology. The capacity factor of HDR plant is about 86%, and the total capital cost is around RM 14,700 – RM 15,000 per kWe¹⁴⁷.

iii. Solar

Solar Energy: Solar thermal and solar photovoltaic are two types of solar energy technologies that are available in the market. For solar photovoltaic the various systems are as below:

- a. Photovoltaic cells from thin film semiconductor (amorphous silicon), copper indium diselenide, cadmium telluride, dye-sensitized cell, with commercial module rated efficiency of 6% – 10%. Total cost for PV systems, with thin film technology is about USD 4.5 – 5 per Watt peak (Wp) or about RM 14,400 – RM 16,000 per kWp¹⁴⁸.
- b. Photovoltaic cells from single crystalline and multi-crystalline silicon wafer, with commercial module are rated efficiency of 12% – 14%. Total cost for PV systems is about USD 5.5 – 6.5 per Watt peak (Wp) capacity or about RM 17,600 – RM 20,800 per kWp.¹⁴⁹
- c. High efficiency Photovoltaic cells, single crystal silicon and multi-junction gallium arsenide alloy cells for concentrator are with 27% – 39% efficiency. Pre-commercial module has 15% – 24% efficiency. Since this technology is not yet commercial, the capital cost for this technology is unknown.

¹⁴⁶ TNA Synthesis Report for Indonesia, 2010

¹⁴⁷ Ibid.

¹⁴⁸ Ibid.

¹⁴⁹ Ibid.

iv. Wind Power Turbine

Small and medium size horizontal axis wind turbines (less than 1 MWe capacity). Economic analysis of installation of a 10 MW wind farm, using Wind Power Conversion System's technology assuming that wind speed is above 7 m/s, the capacity factor is about 20 % and estimated capital cost is RM 4,800 per kWe. Electricity generation cost is about RM 0.32 – RM 0.35 per kWh 2015.¹⁵⁰

The capacity factor small and medium size vertical axis wind turbines for low wind speed (below 7 m per second) is less than 30% and the estimated capital cost is about RM 8,000 –RM 10,200 per kWe.

v. Hydro Power

Hydropower is a power generating technology, which converts the kinetic energy of flowing river water into electric power. Because no fuel is required, power can be obtained without emissions of greenhouse gases (GHG). Plant outputs are from several kW to 30 MW scale and output is affected by the efficiency of the water turbine. The hydro plant system consist of Pico (less than 5KW), Micro (up to 100 KW) and mini hydro (up to 30 MW) power plant. Various types of water turbines have been devised, the most suitable, differs, depending on conditions, for example, with high head/low flow and low head/high flow conditions. Typical capital investment for micro or mini hydro plant varies from RM 6,400 – RM 9,600 per kWe and cost of electricity generation is RM 0.096 – RM 0.128 per kWh.¹⁵¹

Advanced Large Hydro Power: The advance large hydro power system needed for the electricity generation of more than 30 MW. The advance system requires new turbine designs that improve survivability of fish that pass through the power plant.

- a. Types of hydro turbine – Francis, Pelton Wheel, Kaplan and Bulk Turbine. In Malaysia, major power plant are using Francis turbines which is suitable for plant using low to medium head.
- b. Auto venting turbines to increase dissolved oxygen in discharges downstream of dams.
- c. Re-regulating and aerating weirs used to stabilize tailwater discharges and improve water quality.
- d. Adjustable-speed generators producing hydroelectricity over a wider range of heads and providing more uniform instream-flow releases without sacrificing generation opportunities.
- e. New assessment methods to balance instream-flow needs of fish with water for energy production and to optimize operation of reservoir systems.
- f. Advanced instrumentation and control systems that modify turbine operation to maximize environmental benefits and energy production.
- g. Typical capital cost for large hydro plant ranges between RM 4,800 to RM 14,400 per kW¹⁵², depending on various factors.

¹⁵⁰ TNA Synthesis Report for Indonesia, 2010.

¹⁵¹ Ibid.

¹⁵² Ibid.

(C) Cogeneration

i. Combined Heat and Power (CHP)

Combined heat and power production technology (CHP) offers a significant increase in fuel efficiency, which can reduce the GHG emissions. Therefore, it is of interest in relation to GHG emission mitigations. CHP has been applied in the industrial, residential, and commercial sectors and this technology has been installed in the pulp and paper, and food industries. It has high potential for implementation. Combined production of heat and electricity is possible with all heat exchangers and fuels (including biomass and solar thermal) from a low kW rating to large steam-condensing power plants. Heat-plus-power (firstlaw) efficiency is typically 80% – 90%. CHP plants may have an added heat storage that allows the production plant to operate at optimum economy, while fulfilling the heat needs.

Table 4.2.3 shows four typical examples of CHP installations in various sizes, differentiated by their power and heat production, reduction in fuel use, and CO₂ emission, relative to appropriate alternatives for separate supply of heat and power. Combined-cycle power and heat production provide better thermodynamic performance than that of single cycles, even if first-law efficiency is lower, as more electricity is produced. In principle, this electricity may be used with heat pumps to generate more heat at higher temperatures.

Table 4.2.3: CHP installation, fuel and potential CO₂ reduction

Power Plant and Heat Technology	Energy Balance (GJ)			CO ₂ Emission	
	Fuel Input*	Power/Heat Output	Fuel Reduction	Volume (tC)	Reduction by Introducing CHP** (%)
Large Coal Fired CHP Plant	100	36/56		2.4	
Large Coal Fired Power Plant plus Residential Gas Burner	80/59	36/56	28%	2.7	11
Large Coal Fired Power Plant plus Residential Coal Burner	80/112	36/56	48%	3.5	31
Small Biomass-Fueled CHP Plant	100	22/56		0.0	
Large Coal Fired Power Plant plus Residential Gas Burner	49/59	22/56	7%	2.0	100

table continues...

Power Plant and Heat Technology	Energy Balance (GJ)		Fuel Reduction by Introducing CHP	CO ₂ Emission	
	Fuel Input*	Power/Heat Output		Volume (tC)	Reduction by Introducing CHP** (%)
Small Gas Turbine CHP Plant	100	30/55		1.4	
Large Coal Fired Power Plant plus Residential Gas Burner	60/58	30/55	15%	2.2	37
Medium Sized Gas Engine CHP Plant	100	39/46		1.4	-
Large Coal Fired Power Plant plus Residential Gas Burner	78/48	39/46	21%	2.5	45

Source: IPCC SAR: Climate Change 1995, Chapter 19 Energy Supply Mitigation Options

* Arbitrarily fixed reference level.

** Some of the percentage reduction show the combined effect of CHP and fuel switching

(D) Nuclear Power Technology

Commercial nuclear power is dominated by Light Water Reactors (LWR)-type technology. LWR generate power through steam turbines. Similar to those used for power generation by coal or fuel oil. Two models of LWR technology are Pressurized Water Reactor (PWR) and Boiling Water Reactor (BWR). Other reactor types are Pressurized Heavy Water Reactor (PHWR), Water Energetic Reactor (WWER/ VVER), Reactor Bolshoy Moshchnosti Kanalnyy (High Power Channel Reactor) (RBMK), Gas Cooled Reactor (GCR) and Liquid Metal Fast Breeder Reactor (LMFBR). LWR reactors are commonly built and operated in Europe, US and several developing countries.

Advanced nuclear power plant technologies, categorized as III/III+ generation, are now available in the market. Those plants are based on PWR, BWR and PHWR types with evolutionary design. Generation III nuclear reactors are: Advanced Boiling Water Reactor (ABWR), Economic and Simplified Boiling Water Reactor (ESBWR), Advanced Pressurized Water Reactor (APWR), European Pressurized Water Reactor (EPR), AP-1000, System 80+/APR 1400, AES-91 and AES-92 WWER -1000, Advanced Candu Reactor (ACR) and High Temperature Gas Reactor (HTGR).

There are different specific capital costs for current nuclear power plant technologies. IEA/OECD report (2009) reviewed 130 costs for a range of power plants and included a new build of 13 nuclear power plants. The overnight costs for one completed power plant is between RM 3,600 – RM 8,200 per kWe. Costs for an advanced nuclear power plant are higher than the former nuclear power plant. New proposals from US utilities to build an advanced nuclear power generators indicated that the total plant cost varies from RM 17,600 to RM 25,900 per kWe.

Nuclear reactors are assumed to be developed for mitigation options, but are often more costly compared with the older ones. Nevertheless, other aspects of technology performance for nuclear reactors are usually improved and CO₂ emission is reduced, compared to older technology. Table 4.2.4 shows the summary of electricity generation technologies available for GHG emission mitigation.

(E) Carbon Capture and Storage (CCS)

CCS is a technology to prevent large quantities of carbon dioxide or CO₂ (a greenhouse gas) from being released into the atmosphere from the use of fossil fuel in power generation and other industries. CCS can be broadened to include 'utilisation' of the captured CO₂ (CCUS).

CCS/CCUS makes a vital contribution towards greenhouse gas reduction efforts, when partnered with other low-carbon technologies. It reduces the emission of CO₂ from industrial facilities and power stations, and generally involves:

- collecting or capturing the CO₂ produced at large, stationary emission sources;
- transporting it to a suitable storage site and pumping it deep underground to be securely and permanently stored in rock; and/or
- using the captured CO₂ as a value-added commodity or in some cases, reacting it with other compounds, thus locking it into a stable mineral.

This technology can be used in either combustion or gasification. For combustion, post-combustion capture seems to be most appropriate. CO₂ would be removed by scrubbing with solvent such as amine solution. For gasification, pre-combustion capture seems to be more appropriate. CO₂ produced by syngas would be effectively removed by decarbonized through water-gas shift conversion thus left with H₂ as a fuel for downstream application and CO₂ will be captured for storage or other purposes. Oxy-fuel combustion burns the coal in pure oxygen instead of air as the primary oxidant, producing only carbon dioxide (CO₂) and water vapour (H₂O), which are relatively easily separated. Since the nitrogen component of air is not heated, fuel consumption is reduced, and higher flame temperatures can be achieved. The cost for CCS are estimated as in the Table 4.2.5.

Table 4.2.4: Summary of electricity generation technologies

Energy Type	Available Technologies	Policy/Regulatory Intervention
i. Fossil Fuel	a. Combine Heat and Power (CHP) b. Clean Coal Technology (CCT): Super-critical Pulverized Coal, Ultra Super-critical Pulverized Coal; Pressurized Fluidized Bed Combustion (PFBC) c. IGCC	• Regulation on emissions • Carbon Tax on polluters • Tax incentives for Low Carbon Technology • Research and Development • Technology demonstrations • Information dissemination
ii. Biomass	a. Direct combustion for power generation b. Combine Heat and Power (CHP) c. Co-firing with coal d. Gasification (IGCC) e. Biofuels	
iii. Wind	a. Wind turbine generators (low performance wind speed)	
iv. Solar Energy	a. PV Crystalline Silicone b. PV Thin Film c. PV Advance Cell (high efficiency)	
v. Geothermal Technologies	a. Direct use (heat) b. Dry steam c. Flash steam d. Binary cycle	
vi. Hydroelectric	a. Conventional Hydro b. Pump storage c. Advance hydro power technology d. Pico, Micro and Mini-hydro	
vii. Nuclear Power	a. Pressurised Water Reactor (PWR), Boiling Water Reactor (BWR) b. Advance PWR, Advance BWR,	
viii. Transmission and Distribution	a. Higher efficiency transformer b. Higher efficiency transmission cable c. Distributed generation and local grid	

Table 4.2.5: Summary of CCS costs for new power plants based on current technology (excluding CO₂ transport and storage)

Performance and Cost Measures	New NGCC Plant		New PC Plant		New IGCC Plant	
	Low	High	Low	High	Low	High
Total capital requirement without capture (RM/kW)	1,648	2,316.8	3,715.2	4,755.2	3,740.8	5,008
Total capital requirement with capture (RM/kW)	2,908.8	4,035.2	6,060.8	8,249.6	4,524.8	7,264
Plant efficiency with capture, LHV (%)	47	50	30	35	31	40

Source: TERI Analysis 2012 adapted from Energy Commission, 2012

Recommended Technologies Selected

The selection of the technologies are based on the general criteria. The priority technologies are selected based on energy type as previously explained. These technologies are selected, due to the current government policies and targets.

i. Clean Coal Technologies

Clean Coal Technologies (CCTs), such as Subcritical Fluid Bed Combustion (SFBC) technology, will match low rank coal resources, which comprise of more than 50% total coal resources in Malaysia. Adding the CO₂ sequestration technology (i.e., Carbon Capture and Storage) in the near future may reduce the large quantity of coal emissions from these types of power plants¹⁵³. Other types of CCTs, like Supercritical Pulverized Coal and Ultra Supercritical Pulverized Coal are also important to anticipate more utilization of medium rank coal and can be a substitution for the old coal power plants decommissioning in Malaysia grid system. Advanced coal technology can reduce environmental impacts and emissions compared to conventional Pulverized Coal technology in Malaysia. However, since coal power plant technology releasing large emissions, this technology should be considered as an interim solution, before cleaner and more effective coal power plant technologies is available in the market.

The Integrated Gasification Combined Cycle (IGCC) technology is still less competitive compared to other CCTs, due to the high investment cost and the state of the technology itself. The IGCC technology might be more competitive in the coming decades. Advanced coal could be an effective technology, to serve national objectives in securing energy supplies and contributing to the global efforts in reducing GHG emissions, through voluntary mechanisms.

Transfer of technology for advanced coal power plants can be done through market-based mechanisms, such as development of turnkey plants, direct investments and technical licensing agreements; and through non-market mechanisms such as pilot projects between the utility company with technology vendors, and technical assistance from foreign vendors. To enhance the transfer of technology, public- private partnership (PPP) such as the Independent Power Producers (IPPs) can be used to facilitate investment of advanced and clean technology into the country. However, the experience from the implementation of current IPPs needs to be reviewed before embarking in this exercise.

ii. Biomass

Using the Direct Combustion will be suitable for Malaysia to engage using the Biomass technology for power generation. The most important aspect in using Biomass is the availability of the feedstock in Malaysia. Malaysia has an abundance of palm oil

¹⁵³ Assuming that the CO₂ sequestration technology does not produce any leakage which led to higher CO₂ emission in the future

kernel feedstock. It is recommended that the Direct Combustion technology using a palm kernel for power generation to be used in the future. However, it is important to fully identified the other feedstock that can be used to run the system and ensure the sustainability of the technology in Malaysia.

iii. Nuclear Power

The recommended technology for power generation using the nuclear power is using Light Water Reactor (LWR). The most common and advanced technologies in LWR are Pressurized Water Reactor (PWR) and Boiling Water Reactor (BWR). The PWR is the most efficient plant compared to BWR.

iv. Renewable Energy

Besides the clean coal technologies, biomass and nuclear, the renewable energy technologies such as wind, Solar PV, micro and mini hydro can be an option to reduce carbon emissions.

A study by Universiti Malaysia Terengganu indicated that Malaysia has an average wind speed of 4 m/s as in Figure 4.2.3. Further R&D is required before wind technology can be used in terms of its viability and feasibility.

Location	Hub height (m)	Wind Speed (m/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bintulu	10	1.99	1.75	1.81	1.75	1.65	1.78	1.66	1.82	1.72	1.79	1.74	1.72
	100	2.69	2.37	2.44	2.37	2.22	2.41	2.25	2.46	2.32	2.42	2.36	2.32
Kota Kinabalu	10	1.89	1.81	1.92	2.02	2.09	2.33	2.43	2.52	2.60	2.48	2.10	1.88
	100	2.37	2.26	2.41	2.53	2.62	2.91	3.04	3.16	3.25	3.11	2.63	2.35
Kuala Terengganu	10	2.49	1.86	1.84	1.66	1.73	1.79	1.79	1.87	1.57	1.59	1.96	2.65
	100	4.51	3.37	3.33	3.00	3.13	3.24	3.23	3.39	2.83	2.88	3.53	4.79
Kuching	10	2.14	1.86	1.64	1.69	1.65	1.61	1.84	1.74	1.71	1.77	1.72	1.69
	100	3.87	3.37	2.95	3.05	2.98	2.91	3.32	3.14	3.09	3.20	3.11	3.05
Kudat	10	2.1	2.44	2.05	2.56	2.18	2.17	2.53	2.99	3.19	2.77	2.05	2.93
	100	4.03	3.76	3.16	3.94	3.36	3.34	3.90	4.61	4.92	4.28	3.16	4.52
Mersing	10	4.76	3.47	2.40	2.47	2.41	2.62	2.66	2.68	2.55	2.38	2.72	3.51
	100	6.89	5.02	3.47	3.57	3.49	3.78	3.84	3.87	3.68	3.44	3.94	5.07
Pulau Langkawi	10	3.10	2.17	1.77	1.76	1.44	1.63	1.72	2.26	1.85	1.65	1.80	2.90
	100	4.19	2.94	2.40	2.37	1.95	2.21	2.33	3.06	2.51	2.23	2.44	3.92
Sandakan	10	2.83	2.70	2.41	2.19	2.11	2.16	2.02	2.24	2.16	2.24	2.06	2.97
	100	3.83	3.65	3.26	2.96	2.85	2.91	2.73	3.03	2.92	3.03	2.79	4.01
Tawau	10	1.51	1.44	1.56	1.67	1.73	1.88	1.81	1.92	1.88	1.76	1.53	1.79
	100	2.46	2.35	2.56	2.72	2.82	3.06	2.96	3.14	3.07	2.87	2.51	2.92

Figure 4.2.3: Average wind speed in selected areas in Malaysia

Source: Yong et al (2011)

As for PV technology, currently Malaysia technologies are based on the single and multi crystalline technology. The further improvement in the technology, manufacturing of PV modules can be enhanced using both silicon based and advanced thin film technology which are proving to be more efficient. For a large scale PV installation, the technical capacity, the grid connection needs to be carefully studied and developed. Large scale grid-integrated PV systems have been well received and implemented in some developed countries, such as Germany, Spain, Japan, and US. Another important technology transfer for a PV system is building integrated PV, which can transform buildings into power generator.

The main barriers for renewable energy development are their technical limitations, high capital costs and a long payback period, which makes them not favourable and not economically competitive, compared to other conventional fossil fuel based technologies. However, these renewable energy technologies are very suitable to supply energy for remote sites and distributed generation systems. Technology transfers, in this area, should focus on industrial based manufacturing of the technology locally for mass production.

As non-Annex-1 country, Malaysia has no obligation to reduce GHG emissions; however there are discussions to involve developing countries in the global effort to mitigate GHG emissions, within the framework of principles of common, but differentiated responsibilities.

Diversification of energy supplies through renewable energy resources will help to promote and utilize green power generation. Moreover, burning more coal will create large emissions. Therefore, reducing emissions and/or offsetting emissions from energy generating activities, should become the main considerations while, at the same time, considering the energy system cost and economic effectiveness of adopting the technology.

v. Geothermal

The Flash Steam Geothermal technology are currently been build in Sabah. The plant will supply 30 MW of electricity into the grid and expected to be ready in 2014. The Flash Steam technology are selected mainly because of its cost are cheaper than Binary Cycle System and Dry Steam technology.

4.2.3.2 Residential and Commercial Sector

Current Technology Options

In Malaysia, residential refrigerating, lighting, and electric appliances in the middle and high-income households dominate the final energy consumption. For commercial and public buildings, air conditioning/space conditioning and lighting dominate the total of final energy consumption.

(A) Lighting

The amount of energy required to produce light depends on the type of lighting and the behaviour of the energy users. As lighting is considered an energy-consuming sector, it has the potential to be a mitigation option. Substituting incandescent lamps with compact fluorescent lamps (CFL), will increase the illumination efficiency of the lamp by up to 75 – 80%, which leads to a reduction of the electricity consumption. However, investment on CFL is much higher than the incandescent lamp. The price of CFL lamps is about 5 to 6 times higher than conventional incandescent lamp. A typical 15 Watt CFL equals to 75 – 80 Watt incandescent lamp, costs about RM 6– RM 10 per unit.¹⁵⁴

Another mitigation option is the substitution for fluorescent lamps (FL)'s magnetic ballast with electronic ballast and the installation of intelligent switches. A set of 20 Watt fluorescent lamps is about RM 6 – RM 9 per unit. The Light Emitting Diode (LED) lamp is already commercially viable and will have steady penetration of the market. As efficacy increases, LED will be more competitive with the CFL and FL technologies. Currently plans are underway to phase out incandescent bulb by 2015.

The potential of implementation for this option is widely open as the number of residential and commercial buildings increases, giving a potential of an additional 3 – 5 million new households, connecting to the grid, in the next 20 years.

(B) Cooking

Most of the energy demand for cooking in Malaysia is met by Liquefied Petroleum Gas (LPG). The high-energy consumption for cooking is mostly caused by low efficiency of the cooking stoves. Improvement of the efficiency of the current stove technology in Malaysia is estimated to reduce the consumption of fuel. It may offer up to 30 – 40% GHG emissions reduction from cooking activities (KeTTHA, 2010). A higher efficient LPG stove for household cooking costs about RM 160 – RM 220 per unit.¹⁵⁵

¹⁵⁴ Technology Transfer and Assessment of Technology Need Thailand, 2008

¹⁵⁵ Ibid.

(C) Refrigeration

Refrigerant in residential and commercial buildings employs large quantities of HFC refrigerant. Two basic mitigation options are: to reduce leaks and alternative system designs. Refrigerant leakage rates are estimated to be around 30% of banked system charge. Leakage rates can be reduced by system design for tightness, maintenance procedures for early detection and repairs of leakage, personnel training, system leakage record keeping and end-of-life recovery of refrigerant. Alternative system design involves, for example, applying direct systems using alternative refrigerants (usually included in 5-star rating of most efficient refrigerators), better containment, distributed systems and indirect systems or cascade systems. Best available technology for refrigerant system can save 20 – 30% in energy consumption.

(D) Air Conditioning

Room air conditioning in Malaysia is mainly for cooling purposes and the energy consumption is relatively low compared to for heating purposes. The reduction of energy consumption can be achieved through increased efficiency of the room air conditioning equipment and through the improvement of control systems for Air Conditioning (AC) equipment. Rated power for a 1 hp capacity AC can run with electric power of 320 – 350 VA or about 50 – 60% lower than the conventional model.

Another factor that will impact on the energy consumption of AC is human behaviour, such as timing and level of the temperature setting. Setting AC temperature close to room temperature (about 22 – 25°C) can reduce the work of the compressor, therefore reducing electric power input. Moreover, better insulation of room will maintain the cool air inside the room and reduce the work of AC. A study in Thailand found that installing 7.5 cm of insulation in the attic of a typical single-family house would reduce 30% of the air conditioning requirement (Parker, 1991). Table 4.2.6 shows key energy efficient technologies for residential, commercial buildings and industrial and supporting policies and regulation measures to enhance the application of technologies.

Table 4.2.6: Energy efficient technologies for domestic and commercial end users

No.	End Use	Technologies	Policy / Regulatory Intervention
i.	Lighting	• Compact fluorescent lamps (CFL) • Fluorescent lamps with electronic ballast • LED	• Public awareness • Energy labelling programme • Price incentives/discount
ii.	Cooking	• Efficient Cook Stove • Switching to Lower Carbon Fuels	• Public awareness
iii.	Refrigeration	• Efficient compressor/ motor • Better insulation/Leakage reduction	• Energy labelling programme
iv.	Air Conditioning	• Improved insulation system • Higher efficiency Air Conditioner (AC) • Improved Temperature Control • Heating, Ventilation and Air Conditioning (HVAC) System • Passive cooling design(e.g.: roof tiles)	• Building Code • Public awareness

Demand Side Management for GHG Mitigation Options

Other potential mitigation measures through demand side management using more efficient appliances and best practices can also be implemented as follow.

- i. Improvement of the lighting system:
 - a. Replacement of conventional incandescent bulb with compact fluorescent lamp (CFL) and/or tube fluorescent lamp (TFL). This measure can save electricity up to 80% per lamp. Typical cost for a 25 Watt CFL is RM 9 – RM 13 per unit and cost for typical 20 Watt TFL is about RM6 – RM 8 per unit.
 - b. Replacement of magnetic ballast with electronic ballast. The electricity saving is about 20 – 40 %.

- ii. Installing intelligent energy efficient systems:
 - a. Install Building Automatic Systems (BAS). Energy saving can be obtained by installing BAS, particularly in lighting.
 - b. Variable Speed Drive (VSD). Energy saving can be obtained by installing VSD technology on fans and pumps in the commercial building.

- iii. Switching to more energy efficient technologies:
 - a. Using hydrocarbon refrigerant. Energy efficiency can be achieved by replacing the CFC with hydrocarbon refrigerant.
 - b. Install high efficient and energy saving Air Conditioners (AC): Energy saving can be obtained by changing the standard AC with more energy efficient AC. The saving can be obtained by the improvement of the coefficient of performance by 50%.

- iv. Install DSM Peak Shaving Technologies:
Peak shaving technologies mainly consist of two options:
 - a. Alternative energy for heating process, such as using solar thermal as substitution for electricity heating or use CHP/Cogeneration.
 - b. Load management systems (in commercial buildings, etc).

- v. Install Energy Efficiency Technologies:
Energy Efficiency (EE) technologies, which can contribute to peak shifting, primarily concern air conditioning technological options. Efficient technologies may be a combination of one or more among the following options:
- a. Splitting the HVAC system into zones adjusted to solar and other variable loads.
 - b. Usage of primary, secondary and tertiary pump systems with plate type heat exchangers.
 - c. Usage of pre-insulated material rather than conventional ducting.
 - d. Usage of high efficiency recovery wheels in the air handling units for electricity recovery from outlet air.
 - e. Installation of dehumidifier, as required.
 - f. Installation and adjustment of oxygen (new fresh air) in places such as crowded rooms or those containing high levels of carbon dioxide. New high-tech equipment for air conditioning including a new ionizing filter, a new design for its coils in window and mini-split systems, as well as a new scroll technology for its medium-sized refrigeration plants.
 - g. Use of lighting lamps with minimum electricity dissipation in the air.

Recommended Technologies Selected

For residential and commercial sector, priority of technology transfer should be given to:

- 1. Hard technology (Energy efficiency technology):
 - a. Lighting equipment (CFL and electronic ballast)
 - b. Cooling systems
- 2. Soft technology:
 - a. Energy Audit
 - b. Energy Rating and Labelling
 - c. Energy Management

Most of the energy efficient appliances and equipment are widely available in the market and can be easily purchased and installed; therefore the technology transfer in the form of hard technology is not a high priority for the range of these technologies mentioned above. However, transfer of technology in the form of soft technology, is required in order to improve knowledge, skill, and the capacities of public and private institutions that promote and facilitate energy efficiency and programmes for demand side management (DSM).

Energy conservation can be started by implementing low cost measures, such as replacement of inefficient lamps with energy efficient CFL, improving the production process, and installing new and higher efficiency equipment. Therefore, technology transfer is less important, but action through measurable projects and programmes is more important for effective emission reductions.

The existing energy labelling and electrical appliances rating system have to be enhanced to encourage further penetration of energy efficient appliances and equipments. Moreover, specific regulations to promote energy efficiency products need to be strengthened. The Government can also provide legal and regulatory instruments, incentive and disincentive packages in order to encourage more efficient use of energy and DSM oriented actions for residential and commercial sectors.

4.2.3.3 Transport Sector

Specific Criteria for Technology Selection

Specific selection criteria reflect the priorities and situation of the transport sector as listed below:

Table 4.2.7: Specific Criteria for Technology Selection for Transport Sector

No	Specific Criteria	Sub-Criteria
i.	Consistency with national policy & target and specific local situation	• Relevant to existing energy policy & target • Utilization of local energy resources
ii.	Economics and cost-effectiveness of technology	• Total capital cost • Internal Rate of Return • Payback period • Abatement cost
iii.	Technology development	• Advance but proven technology • Possibility for local manufacturing & production
iv.	Social acceptability	• Good impact for socio-economic development

Technology Options Review

GHG emissions mitigation in the transportation sector can be achieved not only through the implementation of certain technologies, but also through so called systems and measures. The list of technologies, systems and/or measures and their explanations are as follows:

(A) Vehicle Technology

A1. Lightweight Material: A 10% weight reduction from a vehicle's total weight, can improve fuel economy by 4 – 8%, depending on changes in vehicle size and whether or not the engine is downsized. There are several ways to reduce vehicle weight including switching to High Strength Steels (HSS), replacing steel by lighter materials such as Aluminum (Al), Magnesium (Mg), and plastics, evolution of lighter design concepts and forming technologies.

A2. Aerodynamic Improvement: Improvements have been made in the aerodynamic performance of vehicles over the past decade, but substantial additional improvements are possible. Improvement in aerodynamic performance offers important gains for vehicles operating at higher speeds, e.g. long-distance trucks and light-duty vehicles operating outside congested urban areas. For example, a 10% reduction in the co-efficient of drag (CD) of a medium sized passenger car would yield only a 1% reduction in average vehicle forces in the city (with 31.4 km/h average speed), whereas the same drag reduction on the highway (with 77.2 km/h average speed) would yield about 4% reduction in the average forces. These

reductions in vehicle forces translate reasonably well into similar reductions in fuel consumption for most vehicles. Variations in engine efficiency with vehicle force may negate some of the benefits from drag reduction, unless engine power and gearing are adjusted to take advantage of the reduction, in terms of fuel.

A3. Econometers and Cruise Control: Econometers permit constant evaluation of the vehicle's fuel efficiency level. An econometer on the car dashboard has two liquid crystal displays (LCDs); the first displaying speed (knots), fuel consumption (litre/hour), and average consumption (litre/hour), while the second LCD displays the total distance (1/10 mile), total consumption (litres), and an efficiency factor. Cruise control (sometimes known as speed control or auto-cruise) is a system that automatically controls the rate of motion of a motor vehicle. The driver sets the speed and the system will take over the throttle of the car, to maintain the same speed. By having econometers and cruise control in the car, bus or truck, it is a lot easier to manage fuel efficiency.

A4. Fuel Cell Technology: A fuel cell produces electricity directly from the reaction of hydrogen and oxygen. The only by-product is water. A fuel cell vehicle utilizes the electricity produced by the fuel cell to power motors at the vehicle's wheels. Fuel-cell vehicles are similar to battery-electric vehicles, in that they are powered by electricity, but they do not have to be recharged like battery vehicles. A fuel cell vehicle has an on-board storage tank, which could be filled at hydrogen filling stations, similar to gasoline vehicle refuelling. Vehicles, which run on pure hydrogen, are true zero-emission vehicles. Some vehicle manufacturers, however, are developing fuel cell vehicles, which use hydrocarbons, such as methanol (a liquid fuel derived most commonly from natural gas) or gasoline. Using hydrocarbons to operate fuel cell vehicles would result in tail-pipe air pollutant emissions, reducing fuel cells' overall environmental benefits. The fuel cell system are still under research and development by major car producers such as Volkswagen and Toyota Motors with expectation of commercialization of the vehicles in 2016.

A5. Improved Exhaust Treatment: Realized in a catalyst trap, exhaust gas re-circulation (EGR), intake and exhaust systems of heavy-duty vehicles and/ or vehicles with limited diesel applications. Technical feasibility: continuation after treatment improvement, thus allowing continued use of the internal combustion engine (ICE). The application of EGR shows a slight decrease for significant NO_x reduction and increased back-pressure reduces efficiency in diesels. The environmental impact is estimated with: up to 97% control of Hydrocarbon (HC) and CO, up to 87% control of NO_x, and up to 85% control for particulate. Market potential within 5 years.

A6. Improved Combustion: Realized in ceramic components, ignition systems, flow-dynamic variable valves and turbine engines improved combustion offers incremental improvements. Technical feasibility: a good variety and availability of technology, should be integrated with current ICE with 5 – 10% engine efficiency gains and also reduces NO_x, particulate and CO₂. Market potential within 10 years.

A7. Fast Warm-Up: Realized in thin walled engines, start/stop, with flywheel storage and incremental improvements. Technical feasibility: transient time decreased by 50%. with 10% average reduction, and <30% reduction in first 60 – 120 seconds. Market potential within 10 years.

A8. Drag and Rolling Resistance Reduction: Realized in drag coefficient reduction, reduced rolling resistance, and reduced bearings friction. There is a commercial potential for improvement in low friction bearings and lubrications. Low-friction tyres are yet to be tested. Technical feasibility: Continuation of improvements, dependent on material properties & cost of manufacture. Has a speed-sensitive benefit, gains of 1 – 5% possible with a reduction of all emissions, in proportion to efficiency gains. Market potential within 10 years.

A9. Structural Weight: Used in light structures, bonded/composite structures, and light power-trains. Commercial/demonstrated bonded structures in limited use and composite materials in most vehicles. Technical feasibility: continuation of improvements, limited by material properties and the relative cost of manufactures. With 0.2 – 0.4% gain for every 1% of weight reduction. Reduction of all emissions, in proportion to efficiency gains, has greater effect on acceleration emissions (urban traffic) as vehicle inertia is diminished. Market potential within 10 years.

A10. Continuously Variable Transmissions (CVT): Realized in drive-lines and suspensions, electronic shift, and multi-step lock-up. Commercial/demonstrated CVT available. High power CVT in prototype Lock-up and electronic control. Technical feasibility: CVT/IVT (Infinitely Variable Transmission) has a widespread use in future years. An Hybrid power-train is feasible' with CVT/IVT registering a 10 – 15% gain over manual while CVT or IVT electronic drives could further increase this conversion efficiency. Reduction of all emissions, in proportion to efficiency gains, engine operations optimized and decreasing emissions even more than efficiency improvement. Market potential within 10 years.

A11. On-board Electronic Control: For constant speed drive and efficient components and it is demonstrated as constant speed systems. Technical feasibility: highly feasible for constant speed, and high efficiency accessory systems, having a 5% efficiency gain. Emission reductions facilitated by on-board electronic controls and sensors. Market potential within 10 years.

A12. Shift Indicator Light: The car's shift indicator light (S.I.L.) is a device designed to help the driver get even better gas mileage from the car. Studies have shown that an optimal fuel economy is obtained by shifting gears at low engine revolutions per minute and high relative engine load. The car's S.I.L. is calibrated to show the driver when to shift for improved mileage- without sacrificing smooth acceleration. The use of the S.I.L. is simple. One has to shift to next higher gear as soon as the light is on. One may find, after using the S.I.L. for some time, that his/her natural shifting rhythm will adapt to the S.I.L.'s suggestion. Some drivers may even shift before the light is on. Obviously, there will be times when one needs to shift later than the light would indicate (for example, when climbing hills or trailer towing). Using the light regularly, however, should result in a mileage improvement of 6% or more, depending on how one normally drives. Market potential within 10 years.

A13. Dual Cooling Circuit: A hydraulic circuit for controlling the application of pressurized cooling fluid to the clutches of a dual clutch transmission, including a cooling unit in fluid communication with a source of the pressurized cooling fluid and adapted to exchange heat from the cooling fluid with another media. The circuit also includes at least one regulator in fluid communication with the source of the pressurized cooling fluid and separately in fluid communication with the cooling unit, and with the clutches. The regulator is adapted to provide the cooling fluid to the clutches. The circuit further includes at least one control actuator, adapted to selectively control the regulator. This can provide a first variable predetermined amount of cooling fluid from the cooling unit to the clutches, as primary cooling, and a second variable predetermined amount of cooling fluid, from the source to the clutches, thereby supplementing the cooling fluid from the cooling unit. Market potential within 10 years.

A14. Tire Inflation Monitor: A Tire Pressure Monitoring System (TPMS) is an electronic system designed to monitor the air pressure inside all the pneumatic tyres on automobiles, airplane undercarriages, straddlelift carriers, forklifts and other vehicles. The system is also sometimes referred to as a Tire Pressure Indication System (TPIS), which reports realtime tire pressure information to the driver of a vehicle - either via a gauge, a pictogram display, or a simple low pressure warning light. TPMS is being used on more and more new vehicles. Low tires are potentially dangerous, especially if a vehicle is heavily loaded and travelling at high speeds during hot weather. A low tire, under these conditions, is a blowout waiting to happen. The inflation pressure of the tires should be checked regularly, but many motorists let it slide. That is why TPMS coming into use. Tires are designed to operate within a certain pressure range. The recommended inflation pressure can usually be found in the vehicle's manual and on a decal, which may be located in the glove box or door jam. The recommended inflation pressure is designed to give the best combination of ride comfort, load carrying capacity and rolling resistance. The maximum cold inflation pressure on the sidewall of a tire is NOT the recommended inflation pressure. It is a maximum limit for the tire only. The recommended inflation pressure for most passenger car tires is 32 to 34psi (cold).

A15. Low Rolling Resistance Circuit: To ensure mobility is environmentally-friendly and possible, tires need to have not only low rolling resistance, but also low rolling noise. This characteristic is measured on two tracks located at some distance from each other, whereby the tire and road noise can be determined. Exterior and interior noise is measured on standardized surfaces. The vehicle's engine, transmission and drives are encapsulated for the test, so that only the rolling noise is measured. These tracks allow rolling noise to be measured on tires for cars as well as for trucks and buses.

A16. Efficient Alternators: The electrical demand in modern trucks, buses and automobiles has dramatically increased as mechatronic electric motor driven devices replace less efficient mechanical and hydraulic subsystems. Radiator cooling fans, water pumps, and air conditioning compressors reduce parasitic loads and increase fuel economy; while mandated safety lighting levels are increased for on road trucks; and the demand for evermore electric motor driven safety and luxury accessories continues. Trucks, buses and specialty vehicles emanating from automobile manufacturers require on-board vehicle alternators/generators with increased power generating capability at both operating and idling speeds to supply the needed power. To increase fuel economy, more efficient alternators are required.

A17. Lubricants Oils (0W-5W/20): It is fully synthetic oil that will keep the engine running smoothly in a relatively long period of time, causing a fuel efficient operation of car.

A18. Electronic Water Pump: Electronic Water Pump (EWP) controllers are used for optimum temperature control. The EWP controller has a microprocessor, which will supply the pump with the voltage that will run it at exactly the right flow rate to maintain the set engine temperature. Set the temperature on the controller for maximum power and fuel efficiency. With the ignition on, the EWP will run on after a hot engine shut down, eliminating heat soak. This option requires the removal of the thermostat and either the mechanical pump impeller from the pump shaft, or the bypass of the water pump pulley from the belt set-up, using a shorter belt.

A19. Heat Battery: Most electricity in cars is used for heating / cooling - the air, the water and the human comfort zone. There is a heat storage tank called Heat Battery that can cut heat-energy usage by 50-70%. Successfully used in Germany, this is currently being launched in the U.K.

A20. Efficient AC Systems or Mobile Air Conditioning (MAC) Systems contribute to GHG emissions in two ways: by direct emissions from leakage of refrigerants and indirect emissions from fuel consumption. Since 1990, significant progress has been made in limiting refrigerant emissions due to the implementation of the Montreal Protocol. The rapid switch from CFC-12 (global warming potential of 8100) to HFC-134a (global warming potential of 1200) has led to a decrease in the CO₂ eq. emissions from 850MtCO₂ eq. in 1990 to 609 MtCO₂ eq. in 2003, despite the continued growth of the MAC system fleet (IPCC, 2005). Refrigerant emissions can be decreased by using new refrigerants with a much lower global warming potential, such as HFC-152a or CO₂, restricting refrigerant sales to certified service professionals, as well as better servicing and disposal practices. Although the feasibility of CO₂ refrigerant has been demonstrated, a number of technical details have still to be overcome. Since the energy consumption for MAC is estimated to be 2.5-2.7% of total vehicle energy consumption, a number of solutions have to be developed, in order to limit the energy consumption of MAC. This includes such improvements of the design of MAC systems, the control systems and airflow management.

A21. Idling Stop/Start (42V System): To meet increasing electrical power demands, auto makers are moving to increase vehicle battery voltage from today's 14V to approximately 42V. Next generation cars will have even more electronics and require a power source with an output of more than 3kW, the limit of today's 14V systems. A 42V system will deliver around 8kW and allow better management of the higher power requirements. A 42V system sets the stage for advanced technologies that will allow a switch from mechanical belt-driven systems to electrically powered ones. Possibilities include electric power steering, electro-mechanical brakes, electrical heating, ventilation and air-conditioning systems, electro-magnetic valve trains, integrated starter-generators and electronic ride control systems.

A22. Heat Pump for AC: The heat pump serves as an air conditioner by absorbing heat from indoor air and pumping it outdoors. The heat pump contains an indoor coil, which, in turn, contains a very cold liquid refrigerant. As indoor air passes over the indoor coil, the refrigerant-cooled coil absorbs heat from the air and so quickly cools that air. The cooled air cannot hold as much moisture as it does at a higher temperature and, thus, the excess moisture condenses on the outside of the coil, resulting in the de-humidification of the air. The cooled, de-humidified air is then forced (by a fan) into the duct system, which, in turn, circulates throughout the building.

A23. Adaptive Cruise Control (ACC): Adaptive Cruise Control is an expansion of the existing cruise control systems, which, in general, maintains vehicle speed through a link in the vehicle's power train. The potential key benefits of ACC systems include the following:

- Reduction in accident rates for vehicles fitted with collision avoidance type systems,
- Reduction in driver fatigue,
- Increase in fuel efficiency due to very gradual speed increase/decrease in traffic, and
- Interconnection to more advanced future systems.

A24. Gasoline Direct Injection (GDI): is the latest variant of fuel injection employed in modern two-stroke and four-stroke petrol engines. The petrol/gasoline is highly pressurized and injected via a common fuel line directly into the combustion chamber of each cylinder, as opposed to conventional multi-point fuel injection that occurs in the intake tract or the cylinder port. Gasoline direct injection enables stratified fuel charge (ultra lean burn) combustion for improved fuel efficiency and reduced emission levels at low load. The major advantages of a GDI engine are increased fuel efficiency and high power output. In addition, the cooling effect of the injected fuel and the more evenly dispersed mixtures allow for more aggressive ignition timing curves. Emission levels can also be more accurately controlled with the GDI system.

A25. 6-Speed Automatic Transmission: Compared to the 5-speed, the 6-speed automatic transmission provides:

- A reduction in fuel consumption;
- A reduction in exhaust emissions;
- Improved acceleration values; and
- A reduction in noise.

A26. No Torque Converter: A torque converter is a modified form of fluid coupling, which is used to transfer rotating power from a prime mover, such as an internal combustion engine or an electric motor to a rotating driven load. Like a basic fluid coupling, the torque converter normally takes the place of a mechanical clutch, allowing the load to be separated from the power source. As a more advanced form of fluid coupling, however, a torque converter is able to multiply torque when there is a substantial difference between input and output rotational speed, thus providing the equivalent reduction gear.

A27. Hybrid Vehicle without Torque Converter: A method for controlling a drive train for a hybrid vehicle is provided. The drive train has at least one internal combustion engine, a torque converter and an operational link to at least one drivable axle, an electrical energy store, and an electrical machine, which is usable as a generator, for charging the electrical energy store during a recuperation operation. The electrical machine is provided on the pump wheel and the operational link is being provided on the turbine wheel of the torque converter. A torque is introduced from the drivable axle, via the operational link and through the turbine.

(B) Alternative Fuel

B1. Cellulosic Ethanol: Cellulosic ethanol is a bio-fuel produced from wood, wood-chips, grass or other by-products of lawn and tree maintenance, from corn stover, switch-grass, miscanthus and other non-edible parts of plants, more precisely from the ligno-cellulose these plants contain. Ligno-Cellulose is a structural material, which is the largest contributor to the mass of plants. It is composed mainly of cellulose, hemi-cellulose and lignin. Production of ethanol from ligno-cellulose has the advantage of using abundant and diverse raw materials, which is an advantage compared to limited sources like corn and cane-sugars. On the other hand it requires a greater amount of processing, to make the sugar monomers available to the micro-organisms that are typically used to produce ethanol by fermentation. Switchgrass and miscanthus are the major bio-mass materials being studied today, due to their high productivity per acre.

Cellulose, however, is contained in nearly every natural, free-growing plant, tree, and bush, in meadows, forests, and fields all over the world, without agricultural effort or cost needed to make it grow. According to the U.S. Department of Energy studies, conducted by the Argonne Laboratories of the University of Chicago, one of the benefits of cellulosic ethanol is that it reduces GHG emissions by 85% over re-formulated gasoline. For comparison: Starch ethanol (e.g., from corn) production mostly uses natural gas to provide energy for the production process and may not reduce GHG emissions at all - depending on how the starch-based feedstock is produced. A study by Nobel Prize winner Paul Crutzen found ethanol produced from corn and sugarcane had a "net climate warming" effect, when compared to oil (Crutzen & Andreae, 1990). The technology is not commercially viable in the market.

B2. Bio-diesel: Bio-diesel refers to a non-petroleum-based diesel fuel consisting of long chain alkyl (methyl, propyl or ethyl) esters and is produced during the transesterification of vegetable oil or animal fat (tallow). It can be used (alone or blended with conventional petrodiesel) in un-modified diesel-engine vehicles. Bio-diesel has to be distinguished from straight vegetable oil (SVO), pure plant oil (PPO) and used vegetable oil (UVO) - sometimes referred to as waste vegetable oil (WVO), which can be used as fuels in converted diesel vehicles (National Biodiesel Board, 2008). Currently bio-diesel (B5) has been implemented in Malaysia on a small scale. B5 has a 5% methyl ester and 95% diesels. The estimated reduction of GHG emission are 0.42 MTCO₂ eq.

B3. Ethanol from Sugar Cane: More than half of the world's ethanol is produced from sugar and sugar by-products, with Brazil being, by far, the world leader. Currently, there is no commercial production of ethanol from sugar cane or sugar beets in the United States, where 97% of ethanol is produced from corn. Technically, the process of producing ethanol from sugar is simpler than converting corn into ethanol. The conversion of sugar requires only a yeast fermentation process, whereas the conversion from corn requires additional cooking and the application of enzymes. The energy requirement for converting sugar into ethanol is about half of that for corn. However, the technology and direct energy costs are two of several factors, which determine the feasibility of ethanol production. Other factors include relative production costs (including feedstock), conversion rates, proximity to processing facilities, alternative prices and government policies, facility construction and processing costs. As other countries have shown that it can be economically feasible to produce ethanol from sugar - and other new sources for feedstock are also researched - interest in ethanol production from sugar has increased.

B4. Compressed Natural Gas (CNG): Compressed Natural Gas is a fossil fuel substitute for gasoline (petrol), diesel, or propane fuel. Although its combustion does produce greenhouse gases, it is a less carbon intense alternative to those fuels, and it is much safer than other fuels in the event of a spill (natural gas is lighter than air, but disperses quickly when released). CNG is made by compressing natural gas (which is mainly composed of methane), to less than 1% of its volume at standard atmospheric pressure. It is stored and distributed in hard containers, at a normal pressure of 200 – 220bar (2,900 – 3,200psi), usually in cylindrical or spherical shapes. CNG's volumetric energy density is estimated to be 42% of LNG's (because it is not liquefied) and 25% of diesel's. CNG is used in traditional gasoline internal combustion engine cars which have been converted into bi-fuel vehicles (gasoline/CNG). Natural gas vehicles are increasingly popular in Europe and South America. Due to rising fuel prices and environmental concerns, CNG is starting to be used also in light-duty passenger vehicles and pickup trucks, medium duty delivery trucks, transit and school buses, and trains (International Association for Natural Gas Vehicles, 2010). The usage of CNG type engine is estimated to reduced GHG emission by 29% lower than the normal diesel and gasoline engine (California Natural Gas Vehicle Coalition, 2010).

B5. Liquefied Natural Gas (LNG): Liquefied natural gas or LNG is natural gas (primarily methane), which has been converted to a liquid form for the ease of storage or transport. LNG takes up about 1/600th the volume of natural gas at a stove burner tip. It is odourless, colourless, non-toxic and non-corrosive. Hazards include flammability, freezing and asphyxia, if inhaled. The liquefaction process involves removal of certain components, such as dust, helium, water and heavy hydrocarbons, which could cause difficulty downstream. The natural gas is then condensed into a liquid at close to atmospheric pressure (maximum transport pressure set around 25kPa or 3.6psi) by cooling it to approximately -163°C (-260°F). The reduction in volume makes it much more cost-efficient to transport LNG over long distances, where pipelines do not exist. Where moving natural gas by pipelines is not possible or economical, LNG can be transported by specially designed cryogenic sea vessels (LNG carriers) or cryogenic road tankers. The energy density of LNG is 60% lower than that of diesel fuel (Eberhardt, 2002). It is expected that the use of LNG engine will reduce GHG emission by 25% of a normal gasoline and diesel-type engine (US Department of Energy, 2010).

B6. Liquefied Petroleum Gas (LPG): Liquefied petroleum gas (also called LPG, GPL, LP Gas or autogas) is a mixture of hydrocarbon gases, used as a fuel in heating appliances and vehicles. It replaces more and more chlorofluorocarbons as an aerosol propellant and a refrigerant, to reduce damage to the ozone layer. Varieties of LPG bought and sold, include mixes that are primarily propane, mixes that are primarily butane, and the more common mixes, including both propane (60%) and butane (40%), depending on the season: in winter more propane, in summer more butane. Propylene and butylenes are usually also present in small concentrations. A powerful odorant, ethanethol, is added so that leaks can be detected easily. The international standard is EN-589. LPG is usually derived from fossil fuel sources, being manufactured during the refining of crude oil or extracted from oil or gas streams, as they emerge from the ground (Qi et. al, 2007).

(C) Transport Demand Management (TDM)

C1. Improved Public Transport: A study was conducted in The Netherland to investigate whether increasing the frequency of buses and trains will attract sufficient numbers of passengers and whether such efforts are economically and environmentally feasible. The result of the study shows that efforts to reduce travelling time for long journeys would be environmentally beneficial. However, the study concludes that doubling of bus and train frequencies will be neither economically nor environmentally viable. The study further proposes the following strategies:

- i. Improvement of conditions for long journeys, i.e. trains and regional bus routes, especially in combination with increased speed. Improvements would be viable if the increased frequency is offset by the introduction of shorter trains. The most significant improvement for long journeys would be better co-ordination between the various buses and trains.
- ii. Efforts should made to improve the coordination of urban and regional traffic involving the flow of buses and trains.
- iii. The introduction of smaller buses would be environmentally beneficial in cases where the service is currently poor, e.g. in rural areas. The introduction of upon-request services etc. would allow greater adaptation to customer demand and result in time savings, with less effort.
- iv. Improving the frequency of public transport and reducing the travel time in the metropolitan area such as Kuala Lumpur city will help to improve the environment.

C2. Intelligent Transportation Systems (ITS): The term intelligent transportation system refers to efforts to add information and communication technology to the transport infrastructure and vehicles to manage factors, which typically correlate with each other: vehicle loads and routes, to improve safety and reduce vehicle wear, transportation times and fuel consumption. Interest in ITS raised because of problems caused by traffic congestion, which could be solved using a synergy of new information technology for simulation, real-time control, and communications networks. Traffic congestion has been increasing worldwide, as a result of increased motorization, urbanization, population growth, and changes in population density. Congestion reduces efficiency of the transportation infrastructure and increases travel time, air pollution, and fuel consumption.

Cost and Benefit Analysis

The cost of installing the above technology in transport sector is quite complex given the variety of technologies available in the market. A simple cost and benefit analysis were conducted for this study.

(A) Vehicle Technology

The hybrid car uses a conventional internal combustion engine (gasoline or diesel) and an electric battery, which helps to decrease engine size, thus reducing fuel consumption. The car battery receives electric energy from the car itself, e.g. through the re-generation of break power when the engine is idling. The energy will be used, when the car needs additional power, e.g. accelerating or manoeuvring. Power support from the battery can reduce fuel consumption significantly in some cases up to 40% compared to the fuel consumption of a conventional engine. Another benefit is that hybrid vehicles do not need new infrastructures such as battery-charging stations.

Today's gasoline engines emit on average of 209.5g CO₂/km. New vehicles in the European Union release lower CO₂ emissions, i.e. 186g CO₂/km and 160g CO₂/km in 1996 and 2005, respectively. The final target of the European Union by 2012 is to operate cars with very low emissions, i.e. 120g CO₂/km. The existing hybrid vehicle emits 80 – 116g CO₂/km.

The abatement cost of a technology is the additional cost to be paid for this technology compared to BAU to reduce GHG emissions by one unit of CO₂. It is estimated as follows: The annual operations and maintenance costs of the old technology are subtracted from the sum of annual investment, operations and maintenance cost of the technology to be introduced and divided by the annual GHG emissions reduction to be achieved by such an implementation.

Table 4.2.8: Examples of Abatement Cost Analysis for Conversion to Hybrid Cars

Car Type	Cost (price and fuel) (RM/year)	CO ₂ emissions (kg CO ₂ /year)	Abatement cost (RM/kgCO ₂)
Gasoline	15,640	5,321.78	4.03
Hybrid	24,230	3,203.41	4.03

Source: TNA for Thailand, 2008

Table 4.2.9: Examples of Abatement Cost Analysis for Conversion to CNG Buses

Car Type	Cost (price and fuel) (RM/year)	CO ₂ emissions (kg CO ₂ /year)	Abatement cost (RM/kgCO ₂)
Diesel bus	18,860	8,162.522	2.55
CNG bus	23,850	6,177.966	2.55

Source: TNA for Thailand, 2008

(B) Transport Demand Management

Transport Demand Management, especially Intelligent Transportation Systems, provides a technological solution to the problem of growing congestion in metropolitan cities. This system is applied to control and manage traffic and the infrastructure, to achieve a safer transportation system, an improved traffic control system and an increased efficiency of transit systems and traffic infrastructure. The development of this system requires a large investment and technically skilled officials. Its benefit is the reduction of traffic congestion and an increased efficiency of energy use in the transportation sector, which will reduce GHG emissions in turn. The implementation of a ITS needs an intense assessment and careful planning to adapt to local transportation systems. General costs and benefits of this technology are shown in Table 4.2.10:

Table 4.2.10: General costs and benefits from installing intelligent transportation system

Technologies	Costs	Benefits	Examples
Intelligent transportation system	Total costs depend on the size of the system and type of technology used	• Reduce congestion, energy consumption, incident and emissions. • Increase road capacity and speed. • Improve transit customer service. • Most aspects of ITS infrastructure contribute to time savings	It cost Singapore Government RM 400 Million ¹⁵⁶ to implement the ITS and public transport system in 1995.

The improvement of the public transport system is one of the GHG emissions mitigation measures with a potential to reduce CO₂ emissions by 30%. The general costs and benefits from improving public transport are described in Table 4.2.11 below.

Table 4.2.11: General costs and benefits from improving public transport

Technologies	Costs	Benefits	Examples
Improvement of public transport	Investment on building railways, operating more trains improving shelters/ stations and other infrastructure change. Transit scheduling and public awareness.	• Reduce total vehicle miles. • Reduce congestion and emissions.	It cost Singapore Government RM 400 Million ¹⁵⁷ to implement the ITS and public transport system in 1995.

¹⁵⁶ Singapore spent around 125 million USD in 1995 for Electronic Road Pricing (ERP). The cost might be higher due to inflationary effect and other adhoc cost incurred in the future.

¹⁵⁷ ibid

Recommended Technologies Selected

Based on the technologies available in the market, the preliminary technologies for technological transfer and measures to reduce GHG emission in the transportation sector can be listed out as below:

Table 4.2.12: Selection of environmental sound vehicle technology

Technology	Benefits on GHG Mitigation	Fuel Savings	Cost (RM)
Continuously Variable Transmission (small cars)	10-15% gain over manual transmission	~ 7%	480 - 640/car
Gasoline direct injection	High fuel efficiency & low GHG emissions load	3 – 4%	400 – 560/car
Lightweight material	Improved fuel economy	4 – 8%	640 – 1,600/car
Fuel cell technology	Fuel efficient operation of car		9,600 – 16,000/car
0W-5W/20 Oil	Engine running smoothly for long period of time		48/litre

The alternative fuel engine technology that have been chosen for the preliminary assessment are summarized as follows:

Table 4.2.13: Selection of alternative fuels

Alternative Fuel	Benefits on GHG Mitigation	Cost (RM)
CNG	Low emission mostly for bus & truck, energy density 25% lower than diesel	0.490/kg
Biodiesel	Low emission non-petroleum based fuel	1.600/litre
LPG	Reduce damage to ozone layer	1.120/kg
LNG	Low emission, energy density 60% lower than diesel	1.600/kg

The transport demand management system that has been chosen is summarized in the Table 4.2.14 below:

Table 4.2.14: Selection of transport demand management

TDM System	Benefits on GHG Mitigation	Cost (RM)
i. Improvement of public transportation	- Lower cost per km per passenger - Less fuel consumption - Reduced travel time - Reduced total kilometre travelled	45 billion for Greater Kuala Lumpur NKEA Programme only
ii. Intelligent transport system	- Increased accessibility - Less fuel consumption	

4.2.3.4 Industrial Sector and Industrial Processes

Specific Criteria

Specific selection criteria reflect the priorities and situation of the industrial sector and industrial processes are listed in Table 4.2.15 below:

Table 4.2.15: Specific criteria for technology selection in industrial sector and industrial processes

Specific Criteria	Sub-Criteria
a. Availability in the market	• Possible for local manufacturing and production • Proven technology • Minimum dependency on technology owner
b. Operations of technology	• Can be operated by the industry itself
c. Efficiency improvement in production process and consumption	• Efficiency in production process • Efficiency in energy consumption
d. Technology Application	• Implementation in Malaysian business environment

Technology Options Review

In analyzing the technology in this sector in ensuring that the production process is more efficient and at the same time optimizing the energy use, it depends on the state of advancement of the particular technology in use in the industrial sector and industrial processes. The review of the condition of technology used in Malaysia will be limited to those energy intensive sub-sectors, namely cements and iron and steel. Generally, technologies to reduce GHG emissions from the industrial sector and industrial processes can be grouped as follows:

- i. **Energy efficiency** - Improve energy efficiency of current boiler, furnace, motor drives, and captive power technologies:
 - Electrical facilities: lighting, water facilities, loads, receiving and distribution systems, air compressors;
 - Heat facilities: heat insulation, steam system, combustion and flue gas, exhaust gas heat recovery; and
 - Utility facilities: heat pump system, cogeneration system, air conditioning, upgrading and process improvement.
- ii. **Fuel switching/ alternative fuels** - Substitute refinery products by fuels with a lower emission factor such as biomass fuels.
- iii. **Recycling** - Recycling is the best-documented material efficiency option for the industrial sector and industrial processes
- iv. Introduce new technology concepts with lower GHG emissions

(A) Cement Industry

About 5% of global CO₂ emissions originate from cement production - about half of it from energy use and half from industrial processes (International Energy Agency, GHG R&D Programme: "Emission Reduction of Greenhouse Gases from the Cement Industry", 23-Aug-2004). In 2005, Malaysia was ranked as the 2nd largest cement producer in the ASEAN (Mahasenan, Natesan; et al.: "The Cement Industry and Global Climate Change: Current and Potential Future Cement Industry CO₂ Emissions", Greenhouse Gas Control Technologies - 6th International Conference, 2003, Oxford: Pergamon, pp. 995–1000).

i. Energy use

Although cement production is energy intensive, progress towards energy use reduction has been made in Malaysia. At the end of the 1980s several cement companies were still using the very energy intensive wet process for their production. Technology substitution from wet- to dry process could reduce energy intensity by about a half meanwhile. Today all companies use the dry process, but still with a variety of technologies, ranging from very efficient to little efficient.

a. Energy efficiency

Industrial systems which may include lighting, compressed air, steam systems, process heating systems, pumps, fans, industrial motors and combined heat and power (CHP) support industrial processes, so they are engineered for reliability rather than energy efficiency. Industrial systems that are over-sized in an effort to create greater reliability can result in energy lost to excessive equipment cycling, less efficient part load operation and system throttling to manage excessive flow. Waste heat and premature equipment failure from excessive cycling and vibration are side effects of this approach that contributes to diminished, not enhanced reliability.

The installation of high-efficiency classifiers during raw material preparation and grinding for example resulted in a higher (raw) material fineness, more stable mill operation, and less mill stops due to rejection of overloads. Furthermore, the use of this technology reduced electricity demand by 1.2kWh/tonne cement with a total energy cost saving of RM 677,000/year. Electricity demand could also be reduced by 1.0kWh/tonne clinker after the installation of adjustable speed drives in raw mill fans, which resulted in total cost savings of RM 164/hour. Another example is the modification of the kiln burner, which led not only to energy savings but also to a sharper flame, which better satisfies process requirements, to an ease of burner operation control, to better coating formation (longer brick lifetime), to the ability to burn alternative fuels, to better clinker microstructure, and hence to a sufficient cement strength according to product portfolio requirements (blended cement).

Another example is the conversion to a grate cooler, particularly the installation of a fixed grate inlet cooler chamber, which improved the cement quality and helped to save energy by reducing the specific heat consumption. The latter was lessened from 3,327MJ/t clinker to 3,091MJ/t clinker, which equals to 7% CO₂ emission reduction from clinker production.

There is potential for the improvement of energy efficiency in the production lines of other cement producers too by using such technologies and measures. Requirements might be producer specific and have to be analyzed.

b. Fuel switching/Alternative fuels

Cement production is an energy-intense production process. Most cement kilns today use coal and petroleum coke as primary fuels, and to a lesser extent natural gas and fuel oil. GHG emissions from stationary fuel combustion in the kiln could be reduced by substituting coal and petroleum coke with alternative fuels e.g. agricultural waste such as rice husk and palm kernel shell and saw dust, instead of fossil fuels. These alternative fuels are assumed to be carbon neutral. Other non-carbon neutral alternative fuels are synthetic fuels, rubber, sorted municipal waste, and crude palm oil (CPO). Except for CPO, prices for alternative fuels are relatively low, because they are waste products. There is a tendency to a price increase for alternative fuels though, due to competition of use, import tariffs, limitations through waste policy, etc. This trend as well as transportation cost of alternative fuels to the production side and supply reliability, which might be limited due to e.g. seasonality, have to be considered by cement producers. Overall fuel cost savings are expected by switching from fossil to alternative fuels. Figure 4.2.4 below shows the cement production process using alternative fuel as being practiced in countries such as Indonesia and India.

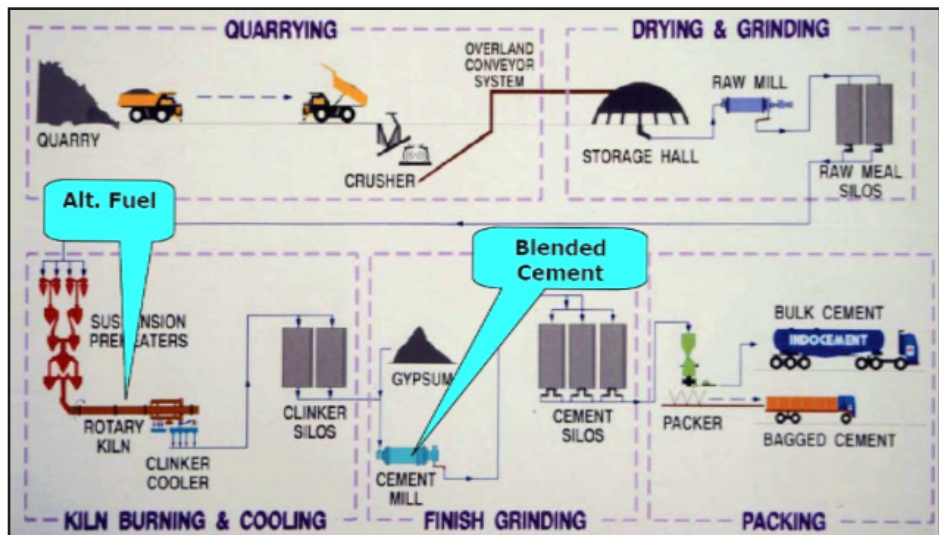


Figure 4.2.4: Cement production process using alternative fuel
Source: www.lafarge.in, last accessed September 2012

ii. Industrial processes

Besides GHG emissions from energy use, CO₂ is released during the production process of clinker, an intermediate product, which cement is made from. High temperatures in cement kilns cause the chemical change of raw materials into clinker. This process is called calcination - calcium carbonate, one of the raw materials for cement production.

a. Blended cement

Clinker production is an emission intensive process. GHG emissions from cement production can be reduced significantly by decreasing the amount of clinker in a cement product. The method is called cement blending - a percentage of clinker in a cement product is substituted by alternative materials such as fly-ash and natural pozzolana such as trass. The percentage of clinker in one unit cement is expressed by the clinker-to-cement ratio. For example, if the company could reduce the clinker-to-cement ratio from 95% to 80% in one of its production units by blending cement, it will translate into a CO₂ emissions reduction during the production process of 12% - 14% (LaFarge Cement India, 2006). Cement blending bears the potential for GHG emissions reduction as it is one of the major players in Malaysia cement sector.

b. Recycled concrete

Recycled concrete is a large part of blended material in some countries, e.g. Netherlands 70% and is growing in prominence as government worldwide attempt to modernize policies dealing with waste from construction and demolition with a view to material efficiency and landfill avoidance. The recovery of concrete falls between standard definitions of reuse and recycling: concrete is broken down into aggregates (granular material), generally to be used in road works, but also as aggregates in new concrete. Recovering concrete has two main advantages: it reduces the use of new virgin aggregate and the associated environmental costs of exploitation and transportation, and it reduces landfill of valuable materials. While in some countries near full recovery of concrete is achieved, in most parts of the world the potential to recover concrete is overlooked and it ends up as unnecessary waste in landfill. This is generally the result of low public concern, as the waste poses relatively low hazard risks compared to other materials.

iii. Other Environmentally Technologies for Cement

The summary of all environmentally sound technologies and measures that can be implemented other than the above can be seen in Table 4.2.16 below:

Table 4.2.16: Environmentally sound technologies and measures for cement industries

Options	Specific Electricity Savings (kWh/t Cement)		Specific Fuel Savings (kWh/t Cement)		Estimated Payback Period
	Lower	Upper	Lower	Upper	
Raw Material Preparations					
Efficient transport system	3.20	3.20	-	-	> 10(1)
Raw meal blending	1.50	3.90	-	-	N/A (1)
Process control vertical roller mill	0.80	1.00	-	-	1
High-efficiency roller mill	10.20	11.90	-	-	>10(1)
High-efficiency classifiers	4.30	5.80	-	-	>10 (1)
Fuel preparation: Roller mills	0.70	1.10	-	-	N/A (1)
Clinkers Production					
Use alternative fuel	-	-	146.54	-	1
Energy Management & Control Systems	1.20	2.60	29.31	58.61	1-3
Seal Replacement	-	-	5.86	5.86	< 1
Shell Heat Loss Reduction	-	-	26.38	90.85	1
Heat recovery power generation	18.00	18.00	-	-	3
Optimize Grate Cooler	1.80	1.80	17.58	35.17	1 – 2
Conversion to Grate Cooler	2.40	2.40	67.41	67.41	1 – 2
Combustion System Improvement	-	-	29.31	114.30	N/A
Indirect Firing	-	-	38.10	55.68	N/A
Low-pressure drop Suspension Pre-heater	0.50	3.50	-	-	> 10 (1)
Addition of Pre-Calcliner or Upgrade	-	-	35.17	158.26	N/A
Conversion of Long Dry Kiln to Pre-Heater	-	-	105.51	213.94	> 10 (1)
Conversion of Long Dry Kiln to Pre-Calcliner	-	-	161.19	322.38	> 10 (1)
Efficient Mill Drives	0.80	3.20	-	-	1
Finish Grinding					
Energy Management & Process Control	1.60	1.60	-	-	< 1
Improved Grinding Media in Ball Mills	1.80	1.80	-	-	8 (1)

table continues...

Options	Specific Electricity Savings (kWh/t Cement)		Specific Fuel Savings (kWh/t Cement)		Estimated Payback Period
	Lower	Upper	Lower	Upper	
High Pressure Roller Press	7.00	25.00	-	-	> 10 (1)
High-Efficiency Classifiers	1.70	6.00	-	-	> 10 (1)
Plant Wide Measures					
Preventative Maintenance (insulation, compressed air systems maintenance)	5.00	5.00	11.72	11.72	< 1
High Efficiency Motors	5.00	5.00	-	-	< 1
Adjustable Speed Drives	5.50	7.00	-	-	< 1
Optimization of Compressed Air Systems	2.00	2.00	-	-	< 3
Efficient Lighting	0.50	0.50	-	-	N/A
Product Change					
Blended Cement	15.00	15.00	354.62	354.62	< 1
Limestone Portland Cement	3.00	3.00	87.92	87.92	< 1
Use of Steel Slag in Clinker (CemStar)	-	-	46.89	46.89	< 2
Low Alkali Cement	N/A	N/A	46.89	117.23	Immediate
Reduced Fineness of Cement for Selected Uses	14.00	14.00	-	-	Immediate

Source: Ernst Worrell and Christina Galitsky. "Energy Efficiency Improvement Opportunities for Cement Making: An ENERGY STAR® Guide for Energy and Plant Managers", Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, January 2004, LBNL-54036

Notes: Payback periods are calculated on the basis of energy savings alone. In reality this investment may be driven by other considerations than energy efficiency (e.g. productivity, product quality), and will happen as part of the normal business cycle or expansion project. Under these conditions the measure will have a lower payback period depending on plant-specific conditions.

(B) Iron and Steel Industry

The steel industry is one of the major energy intensive industry sub-sectors, utilizing fossil fuels for energy use. The World Steel Association ranked Malaysia as the 31st among the world's major steel producing countries in 2010, sharing the position with Slovakia. Currently there are nine iron and steel plant operating in Malaysia with seven companies producing 85% of the 5.9 million tonnes of steel in 2010 (The Star, 2011). According to Malaysia Iron and Steel Industry Federation (MISIF), most iron & steel producing companies have not yet implemented energy efficiency measures in their production lines, therefore bearing a significant optimization potential.

i. Energy use

The high share of electricity in the Iron & Steel industry's energy mix makes electricity generation a process to be analysed for optimization potential. Also the energy efficiency of production processes for iron making, steelmaking and rolling have to be further examined. Energy audits and energy management systems could to be utilised in steel plants to identify opportunities for reducing energy use, which in turn reduces GHG emissions.

a. *Energy Efficiency*

Approximately 10% of total energy consumption in steel making could be saved through improved energy and materials management. The potential for energy efficiency improvement varies between steel plants based on the production route used, product mix, energy and emissions intensities of fuel and electricity, and the boundaries chosen for the evaluation (IPCC, 2007).

Opportunities for efficiency improvement during steelmaking are presented in the following figure.

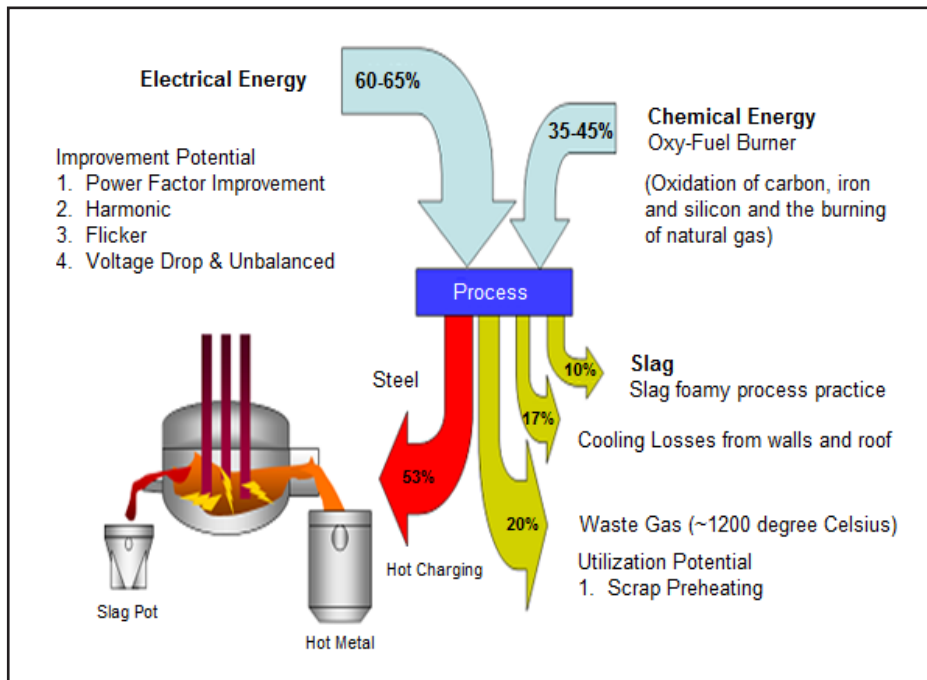


Figure 4.2.5: Opportunities for Energy Conservation in Steelmaking Process

Source: Krakatau Steel, Indonesia, 2006

Fuel Switching

Fuel switching, including the use of waste materials, is mentioned as an energy conservation measure for the Iron & Steel industry. Technology to use wastes such as plastics as alternative fuel and feedstock for steel production has already been developed. Pre-treated plastic wastes can be recycled in coke ovens and blast furnaces, reducing GHG emissions by reducing both emissions from incineration and the demand for fossil fuels (IPCC, 2007).

Recycling

Recycling is the best-documented material efficiency option for the industrial sector and is used already in steel production. Recycling of steel in electric arc furnaces accounts about a third of world production and typically uses 60–70% less energy (IPCC, 2007). Recycling will also result in the reduction of the amount of coal used as a reducing agent in the Iron & Steel making process and in an overall reduction of GHG emissions from industrial processes.

Table 4.2.17: Environmentally sound technologies and measures for iron and steel sectors

Option	Fuel Savings	Electricity Savings	Primary Energy Savings	Annual Operating Cost	Retrofit Capital Cost	CO ₂ Emissions Reduction.*
	(kWh/t crude steel)			(RM/t crude steel)		(kgC/t)
Iron Making – Blast Furnace						
Pulverized coal injection to 130kg/thm	191.67	-	191.67	(5.70)	19.97	11.42
Pulverized coal injection to 225kg/thm	141.67	-	141.67	(2.85)	14.85	8.45
Injection to natural gas to 140kg/thm	222.22	-	222.22	(5.70)	14.27	13.35
Top pressure recovery turbines (wet type)	-	27.78	83.33	-	57.09	4.29
Recovery of blast furnace gas	16.67	-	16.67	-	0.86	5.49
Hot blast stove automation	91.67	-	91.67	-	0.86	5.49
Recuperator hot blast stoves	19.44	-	19.44	-	4.00	1.19
Improved blast furnace control system	100.00	-	100.00	-	1.02	5.93
Steelmaking – Basic Oxygen Furnace						
BOF gas + sensible heat recovery	255.56	-	255.56	-	70.40	12.55
Variable speed drive on ventilation fans	-	-	2.78	-	0.64	0.14
Integrated Casting						
Adopt continuous casting	66.67	22.22	136.11	(17.12)	38.24	36.06
Efficient ladle pre-heating	5.56	-	5.56	-	0.16	0.27
Thin slab casting	869.44	158.33	1,358.33	(100.26)	429.60	177.60
Integrated Hot Rolling						
Hot charging	144.44	-	144.44	(3.68)	41.88	7.18
Process control in hot strip mill	72.22	-	72.22	-	1.95	3.59
Recuperative burners	169.44	-	169.44	-	6.97	8.38
Insulation of furnace	38.89	-	38.89	-	27.94	1.91
Controlling oxygen levels and VSDs on combustion air fans	80.56	-	80.56	-	1.41	3.95
Energy-efficient drives (rolling mill)	-	2.78	8.33	-	0.54	0.39
Waste recovery (cooling water)	8.33	-	8.33	0.192	2.24	0.46

table continues...

Option	Fuel Savings (kWh/t crude steel)	Electricity Savings	Primary Energy Savings	Annual Operating Cost (RM/t crude steel)	Retrofit Capital Cost	CO ₂ Emissions Reduction.* (kgC/t)
Integrated Cold Rolling and Finishing						
Heat recovery on the annealing line	47.22	2.78	52.78	-	4.96	2.73
Reduced steam use (pickling time)	30.56	-	30.56	-	5.15	1.55
Automated monitoring and targeting system	-	33.33	105.56	-	2.02	5.51
General						
Preventive maintenance	119.44	5.56	136.11	0.064	0.03	9.74
Energy monitoring and management system	30.56	2.78	28.89	-	0.48	2.60
Cogeneration	8.33	97.22	305.56	-	46.46	22.39
Variable speed drive: flue gas control, pumps, fans	-	5.56	16.67	-	4.16	0.40

Source: Ernst Worrell, Nathan Martin, and Lynn Price. "Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the U.S. Iron and Steel Sector", Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, July 1999, LBNL-41724

Notes: * denoted the Primary energy saving is calculated based on the average efficiency of power plants in US as well as transmission and distribution losses in US.

Recommended Technologies Selected

For energy manufacturing activities, priorities should be given to the following technologies:

Energy efficiency technologies for industrial sector such as:

- Lighting systems
- Pump and Fan
- Industrial Motor
- Cogeneration using available feedstock in the industry

Transfer of technology should be encouraged and promoted for technologies related to industrial processes, in particular energy intensive industries such as steel, pulp and paper, cement, chemical, textile, and petroleum refining:

1. Energy efficiency technology for the iron and steel industry such as: electric arc furnace (EAF) to replace blast furnace (BF)/basic oxygen furnace (BOF), smelting reduction, near net shape casting, scrap preheating and dry coke quenching, substitution of coke and coal with plastic waste for injection to blast furnace.
2. Energy efficiency technology for the cement industry such as pre-calciner kilns and roller mills.

On the industrial processes activities, the following Table 4.2.18 and Table 4.2.19 summarize the priority of the technologies based on the stakeholders feedback to reduce the GHG emissions for cement sector, iron and steel sector.

Table 4.2.18: Priority technologies for cement industry

No	Technological Options
1.	Use of limestone with low Calcium Carbonate (CaCO_3)
2	Alternative fuels
3	Reducing clinker-to-cement ratio by substituting clinker with materials such as fly ash, etc.
4	High-efficiency classifiers
5	Mineral components in Cement (MIC)
6	Energy management and process control system
7	Preventative maintenance (insulation, compressed air system, maintenance)
8	High-efficiency motor drives
9	Install variable speed drive
10	Waste heat recovery of cement kiln exhaust gas for raw meal pre-heater

Table 4.2.19: Priority technologies for iron and steel industry

No	Technological Options
1.	Slabs/ billets hot charging
2	Thin slab mills technology (hot rolling)
3	Scrap pre-heater (steelmaking)
4	Oxygen lancing at electric arc furnace (steelmaking)
5	Fuel substitution
6	Energy monitoring and management system
7	Waste heat recovery
8	Zero reformer
9	Preventative maintenance
10	Energy-efficient drives (rolling mill)

4.2.3.5 Waste Sector

Specific Criteria

The specific criteria for waste sector are shown as follows:

Table 4.2.20: Specific criteria for technology selection in waste sector

Specific Criteria	Sub-Criteria
General Concern on Waste Management	• General concern close connection to the local market (solid waste)
	• Support of sustainability
	• Alignment with regulations
	• Alignment with traditional characteristics (wastewater)

On the implementation level, some other criteria should be followed. For example, selection of the final disposal site must be in line with the regulation by the MHLG. In addition to that, the implementation of incinerator, the community condition near the location should also be considered. For the 3R application, the motivation of the community, composition and the characteristic of waste are very important to be considered. Whereas for the Intermediate Treatment Centre, in which the 3R would be applied, it should be differentiated between big, medium and small cities.

Technology Options Review

(A) Sanitary Landfill with Landfill Gas (LFG) Recovery

The disposal of Municipal Solid Waste (MSW) produces significant amounts of methane (CH_4) and carbon dioxide (CO_2). Methane produced at Solid Waste Disposal Sites (SWDS) contributes approximately 3–4% to the annual global anthropogenic greenhouse gas emissions (IPCC, 2001).

Globally landfill gas (LFG) recovery has become a more common technology to reduce CH_4 emissions from SWDS. In Malaysia, the transfer of LFG recovery technology and its methodology is still needed. Such LFG recovery technology should be suitable for CH_4 recovery both in open dumpsites and sanitary landfills.

The country also needs sanitary landfill technology, which is suitable for Malaysian conditions and can replace the currently used open dumpsites. The replacement of open dumpsites by sanitary landfills will not directly reduce GHG emissions, but it can improve the overall environmental conditions. A reduction of GHG emissions from sanitary landfills can be achieved by adding an LFG recovery system.

Based on the experiences of sanitary landfill development in other country such as Korea and Thailand and on other research results, the application of sanitary landfill technology in remote areas (inland areas) need a budget of RM 960,000/ha – RM 1,600,000/ha (in coastal areas a budget of RM 1,280,000/ha – RM 1,920,000/ha has to be calculated). The difference originates from a different ground lining work factor. The benefit will be gained by deciding the tipping fee to RM 19 to RM 32/tonne MSW with 6,000 tonnes/day and the minimal tolerance waste input is 800 tonnes/day. The operational and maintenance budget is around RM 9.60 to RM 13/tonne MSW.

(B) Composting

Composting is an aerobic process, where a large fraction of the degradable organic carbon (DOC) in the waste material is converted into CO₂ and compost. CH₄ is formed in anaerobic sections of the compost, but is oxidized to a large extent in the aerobic section of compost. The estimated CH₄ released into the atmosphere is only less than 1% of the initial carbon content in the material (IPCC, 2006). It means that composting can avoid the methane production from MSW.

The low-tech system of composting is widely used in as windrow composting systems. If an open windrow system is treated in the proper way, it will generate a high quality compost. Such system is operated manually involving the support of scavengers to segregate the waste. A composting technology, which can produce high quality of compost is needed, because of the high demand for compost (organic fertilizer) for organic agriculture. There are several composting technologies that can produce high quality compost under tight controlled conditions such as the mechanical windrow system.

Based on best practice of composting, an application of low-end composting technology needs an upfront investment of RM 32,000 – RM 64,000/tonne cap/day. The associated costs for maintenance and operations are calculated with RM 64/tonne – RM 130/tonne. High-end composting technology requires an upfront investment of RM 80,000 – RM 160,000/tonne cap/day with associated costs for maintenance and operations of RM 100/tonne – RM 160/tonne MSW.

(C) Anaerobic Digestion

Anaerobic digestion of organic waste expedites the natural decomposition of organic material without oxygen by maintaining the temperature, moisture content and pH close to their optimum values. It produces CH₄ that can be used for producing heat and/or electricity. The other gas, CO₂ emission, is of biogenic origin. N₂O emissions from the process are assumed to be negligible.

Anaerobic digestion is also a common method in Malaysia. It is popular for treating wastewater in an oil palm industry. Unfortunately, the experience of anaerobic digestion for treating solid material of MSW is limited. Technologies involve low-solid anaerobic digestion, high-solid anaerobic digestion and combined high-solid anaerobic digestion/ aerobic composting. The transfer of these specific technologies to Malaysia is still needed. Based on the reference of countries, which have already applied the technology, the investment cost for anaerobic digestion is between RM 2,900/m³ – RM 3,200/m³ waste.

(D) Mechanical-Biological Treatment

Mechanical-biological treatment (MBT) of waste is becoming popular in Europe. During MBT, the waste material is processed in a series of mechanical and biological operations with the aim to reduce its volume, as well as to stabilize it. GHG emissions from the final disposal site can be reduced that way.

The operation varies in application. Typically, the mechanical operation separates the waste material into fractions that will undergo further treatment (composting, anaerobic digestion, incinerating, recycling). This may include separation, shredding and crushing of the material. The biological operation includes composting and anaerobic digestion. The composting can take place in heaps or in composting facilities with optimization of the conditions of the process as well as filtering of the produced gas. The possibilities to reduce the amount of organic material to be disposed at landfill are large (40 – 60%).

Due to the reduction of the amount of the material, the organic content and the biological activity, the MBT will produce up to 95% less CH_4 than untreated waste when disposed to SWDS. The practical reductions have been smaller and depend on the type of MBT. CH_4 and N_2O emission during the different phase of the MBT depend on the specific operations and the duration of the biological treatment (IPCC, 2006). Malaysia experiences of MBT are still limited. This kind of technology needs to be improved in the country.

The application of low-mechanical intensity MBT technology needs an upfront investment of RM 32,000 – RM 64,000/tonne cap/day and maintenance and operations costs of RM 64/tonne – RM 130/tonne. For high-mechanical intensity MBT technology investment costs are calculated with RM80,000 – RM 160,000/tonne cap/day and cost for maintenance and operations with RM 100/tonne – RM 160/tonne.

(E) Incineration

Waste incineration is defined as combustion of solid and liquid waste in controlled incineration facilities. Modern refuse combustors have specially designed combustion chamber, which provide high combustion temperatures, long residence times and efficient waste agitation for more complete combustion. Incinerations are the source of GHG emissions of i.e. CO_2 , CH_4 and N_2O . The flue gas treatment is very important in applying the incineration in order to clean the emitted pollutants, such as CH_4 and N_2O but usually not for CO_2 .

Big capacity incinerators or incinerator flue gas treatment has not been implemented in Malaysia yet. Such system can potentially be applied in big cities such as Kuala Lumpur, Johor, Penang and Shah Alam. If incinerators are planned to be used for burning MSW, they must be chosen by considering their efficiency of combustion and a low concentration of resulting pollutants. Incineration systems are combustion (stoichiometric air) such as mass-fired, RDF-fired, fluidized bed; gasification (substoichiometric air) such as vertical fixed bed, horizontal fixed bed, fluidized bed; and pyrolysis (no air) such as fluidized bed system. The erection of mass burn fields or the application of modular technology needs an upfront investment of RM 256,000 – RM 384,000/tonne cap/day. Maintenance and operation costs are calculated with RM 130/tonne – RM 260/tonne.

Recommended Technologies Selected

As already described in the general (Table 4.2.1) and specific criteria (Table 4.2.20), the technology selection for the waste treatment should be based on these criteria and also support Malaysia Low Carbon Economy pathways.

For the stakeholders to make a decision on the technology, a priority list has been made as follows:

- Insitu Composting
- Sanitary Landfill with LFG Recovery with minimum flaring facilities
- Mechanical-Biological Treatment (MBT)
- Waste to energy incinerator
- Anaerobic digestion

Based on the discussion with various stakeholders and industry expert, the technology assessment was made and the priority lists for Intermediate Treatment Facilities (ITF) are as follows:

1. Composting
2. Sanitary Landfill with LFG Recovery with minimum flaring facilities
3. Waste to energy incinerator
4. Anaerobic digestion for POME

4.2.3.6 Agriculture Sector

Extreme climate has become a threatening factor for agricultural vulnerability in Malaysia in recent years. Floods and droughts have had serious impact on agricultural productivity, especially food crops. Malaysia Government through the Ministry of Agriculture and Agro-based Industry has directed efforts to create awareness of the impact of climate variability and the dynamics of extreme climate. The implementation of action plans to these ends is expected to lead to sustainability in the agriculture sector in the country.

Greenhouse gas (GHG) emissions mitigation efforts to reduce the cause of climate change are urgent and should be executed comprehensively and as an integrated action together with climate change adaptation activities. Several GHG emissions mitigation strategies may be introduced. These strategies can be differentiated into:

- Land and water management - Intermittent irrigation for rice fields is one of the strategies of land and water management, which may reduce methane (CH₄) emission. It is urgent to assist farmers in implementing water management systems for their rice fields. In general, farmers prefer to maintain the water standing in the rice fields as high as 20cm instead of draining it after a period of 2 - 4 weeks. As a result a large amount of CH₄ is emitted from the rice fields.
- Introduction of crop varieties - The variation of crops can result in less GHG emissions.
- Integrated crops-livestock management - Integrated crops-livestock management is another strategy, which helps to reduce GHG emissions. Manure can be converted into compost to be used as fertilizer later. Fresh manure, which may not emit GHG such as CH₄, can be converted into biogas to produce energy for electricity, cooking and other purposes.

Each strategy shall be implemented in consideration of local farming characteristics. Despite their importance for food security, agricultural resources can also be used as alternative sources of energy. Since the limited oil resources became a critical issue in the last decade, alternative energy sources have to be used to fulfil the increasing energy demand. It has to be considered though, that alternative energy sources originate among others from agricultural products such as maize, cassava, etc., which might become a threat for the provision of food security. The use of non-food crops can be a strategy to achieve both food and energy security.

The use of manure for biogas production is one of the best alternatives to produce energy. This should be in line with the programme of livestock development at the village level. Other materials such as crop residues and other agricultural by-products are also recommended. It would be unwise to produce energy from food crops, which are still relatively limited.

Technology Selection Criteria

Criteria used for technology selection includes general and sector-specific which are used to identify technologies for mitigation to climate change. In general, technologies for mitigation are selected based on their potential reduction of GHG emissions and the characteristics of crops and animals which can be adapted to the environment influenced by the climate change. The specific criteria of the sector are based on the site and users of a particular mitigation and adaptation technology.

The criteria for selecting technologies for TNA of the agricultural sector are based on three considerations, which are:

1. The technologies should contribute to three important goals of realizing food security, increase farmers' income, and agribusiness development. The technologies should be economically beneficial, socially acceptable, and environmentally benign.
2. The technologies should address climate change mitigation which reduces GHG emissions (e.g. low emission of crops varieties, composting, etc.) and enhance carbon sink. The contribution to climate-change adaptation could involve an assessment of the degree to which climate change related risks can be reduced by a particular technology, is also important.
3. The contribution to market potential which can involve an analysis of capital and operating costs relative to alternatives, the commercial availability of the technology, and the technology's replicability, applicability, adaptability, and potential scale of utilization. Selected technologies are based on criteria and priority options of technology needs. Technology needs are country-specific, economically profitable, socially acceptable, and environmentally friendly.

Technology Options Review

Several GHG emissions mitigation technologies for the agriculture sector are listed below:

1. Climate Prediction

- Climate database
- Climate Prediction Model
- Information Technology of climate forecast

2. Rice

- Crop varieties development - Rice varieties with a lower CH₄ emission potential have been developed. For example, the Way Apo rice variety has a lower CH₄ emission potential than the Cisadane rice variety.
- Intermittent irrigation for rice fields - Farmer cultivate rice by using water in the rice fields, which stands 20cm above the soil surface. This results in a higher amount of CH₄ emissions compared to dry conditions. Intermittent irrigation is an alternative way to reduce CH₄ emissions, because this irrigation technique supports alternating dry and wet conditions during the cycle of irrigation.
- Drip and sub-surface irrigation for estate crops - Controllable drip and sub-surface irrigation, at certain moisture conditions may provide circumstances that balance moisture and air in the soil, helping to avoid frequent conditions of soil reduction and reducing CH₄ emission.

3. Livestocks

- Composting manure and crop residues - Substantial amounts of manure are produced from community cattle breeding. Without processing this manure, GHG emissions are relatively high. Composting is an alternative way to reduce these GHG emissions.
- Biogas production for energy use - Production of biogas means converting manure into gas, which can be used as an energy source and therefore reduces GHG emissions.
- Bio-fuel production - Agricultural resources such as agro-industrial waste and other agricultural residues from livestock are used to produce bio-fuels.

Recommended Technologies Selected

Mitigation measures, through crop management, with fertilizing and no tillage technology are also implemented as a means of reducing GHG emissions from the agricultural sectors. Water resources management should also be considered, where intermittent irrigation, drainage to reduce CH₄ emissions and the introduction of rain-fed rice are priority technologies. Another priority could be the adaptation of livestock to areas affected by climate change, the introduction of the most-adaptable livestock such as cattle for dry or wet climate areas and the introduction of the technology of communal livestock as well as integrated livestock management. Mitigation may also be introduced through biomass (manure) processing, as well as composting manure and converting it into biogas. Since peat soils are fragile, adaptation and mitigation technologies need to be implemented in appropriate ways. Through land and water management, several priority technologies will be implemented including minimum tillage, balanced fertilizing, appropriate soil amelioration, drainage and land-subsidence control, and peat dome area conservation.

Table 4.2.21: Selected technologies/ measures for mitigation

Agriculture subsector	Priority Technologies	Climate Prediction
Rice field	a. Appropriate fertilizing b. No tillage c. Intermittent irrigation	Climate database Management Climate information technology Climate model development
Livestock	a. Composting manure b. Biogas production c. Avoiding over drain d. e. Maintaining soil moisture	

4.2.3.7 Land Use, Land-Use Change and Forestry Sector

Technology Selection

LULUCF is a unique sector, the problems in management are complex and, in most cases, the barriers are more on institutional aspects rather than technology. For this reason, assessment of technology needs in this report was undertaken not only to identify the needs for technology support, but also to incorporate capacity-building needs as well as raising awareness.

The selection of technology in the LULUCF will be based on Malaysia policy framework. The technology introduced will be based on the 2 broad categories with various programmes and activities within the categories:

1. Sink Maintenance
 - Industrial forest plantation
 - Rehabilitation / Restoration
 - Reducing the rate of forest conversion
2. Emission reduction
 - Management improvement of natural resources
 - Curbing illegal logging
 - Forest fire prevention and control

Recommended Technology Selection

Sustainability of forest resources is crucial for the continuation of national development. Sustainable management of forest resources is a form of mitigation and adaptation measures, which is a survival issue for Malaysia. Table 4.2.22 describes the results of identification of technology needs for mitigation of climate change in the LULUCF sector.

Table 4.2.22: Technologies recommended for LULUCF

No.	Program/ Activities	Selected Technology
SINK ENHANCEMENT		
A.	Industrial Forest plantation	• Silvicultural technology • Growth and yield modeling technology • Advanced Tree improvement • Pest, disease, weed and fire management
B.	Small scale forest plantation	• Silvicultural technology • Site species matching • Pest, disease, weed and fire management
C.	Rehabilitation/restoration	• Site species matching
D.	Monitoring Carbon Sequestration	• Carbon related measurement and monitoring for carbon sequestration activities
EMISSION REDUCTION		
A.	Management improvement of natural forests	• Reduce-Impact-Logging (RIL) in production forest
B.	Curbing Illegal Logging	• Use of Molecular Biology to support chain of custody (e.g. DNA analysis for log tracking)
C.	Forest fire prevention and control	• Zero burning concept
D.	Monitoring Carbon Sequestration	• Carbon related measurement and monitoring for reduced emission activities

Mitigation to climate changes in the LULUCF sector have already been instilled in forestry policies and programmes. Challenges to these policies need to be enhanced, not only through technological support, but also capacity building and the raising of awareness on conserving our forest. Technology, capacity building and creating awareness level to support policy implementation should include all those mechanisms under CDM, REDD+, and other carbon-trading entities.

Technological options in the future are based upon sustainable forest management criteria that includes production, social impact and environmental aspects. Moreover, the availability of state-of-the-art technology, that significantly can improve the sustainable forest management, should also be considered. One such example is forest that characterizes slow growth and presents extensive areas that need protection would require silviculture technology, biotechnology and tree improvement to raise the quality and quantity of woods as carbon sink, as well as technology in forest protection (from pest, disease, weed and fire). However, because the vulnerability of forest resources also relates to human activities, capacity-building and awareness need to be improved. In relation to carbon accounting, the application of more advanced technology and tools for monitoring carbon sequestration is required.

The technology needed to improve forest practices towards sustainable forest management and thus contributing positively to climate change mitigation, includes: technology of tree improvement and biotechnology to improve quality and quantity of woods as carbon sink, as well as technology in forest protection, carbon accounting and monitoring.

4.2.3.8 Adaptation Technologies

In the context of climate change, much emphasis has been given to mitigation strategies including technologies to reduce atmospheric GHG concentrations by reducing emissions and enhancing sinks. However, technologies for adaptation to climate change are much more diverse.

Criteria in Selecting Adaptation Technologies

The limited available resources necessitate the need for governments and industries to use a number of criteria, priorities and tradeoffs in selecting and deciding the timing of implementation of adaptation technologies. Some of the common criteria for decision makers are related to flexibility, efficacy, economic efficiency, equity, environmental sustainability, social and political acceptability. A four step method to identify and analyze anticipatory planned adaptation technologies proposed by Smith (1997) are as follows:

- Analyze the systems susceptibility or potential impact to climate change
- Select the resources required where adaptation would be a high priority
- Analyze sensitivities of current policies to climate change
- Examine the relative effectiveness of anticipatory planned adaptation technologies

Some of the examples of technologies for adaptation include air conditioning, flood-defence systems, and irrigation, but also monitoring, forecasting and early warning systems for natural hazards. These technologies can be used for adaptation to climate change and new technologies developed because the effects of climate change is likely to exact new and higher standards of reliability and performance.

1. Health Sector

- Improving access to cool air and filters to the wider population to prevent heat exhaustion during the hot climate and improve the air quality within the premise
- Improving vaccines and antibiotics to protect against diseases due to climatic changes
- Improving monitoring and early warning systems on the impact of climate change

The health sector vulnerability to climate change are due to heat stress, extremes of high wind and water, vector/water/food borne diseases, and plant aeroallergens. Various technologies are recommended for the adapting to the climate change.

Heat stress

- air conditioning
- review building designs to improve ventilation
- heat transfer,
- insulation
- wear protective clothing
- light fabrics and sunglasses

High Wind Extremes

- Tree planting in urban and rural areas
- Strengthening of building structures
- Early warning detecting systems
- Disaster preparedness initiatives,

High Water Extremes

- Better flood defence systems and structures
- Better mobility between areas
- Early warning systems
- Disaster preparedness programmes against coastal and riverine floods

Vector Borne Diseases

- Vector control approaches (fumigation)
- improve primary health care including vaccinations and better medicines
- improve public health surveillance and control programmes, urban/rural area – provide mosquito netting, repellents and wire gauze for window screens and doors.

Water/Food borne Diseases

- Improve water supply systems
- Provide better water purification systems
- Improved sanitation,
- Improve primary health care
- Better vaccination and medicines
- Public health surveillance and control programmes
- Better environmental management
- Increase awareness on personal hygiene at home and food outlets

Plant aeroallergens

- Allergy warning systems
- Develop better anti-allergens and other medication

Table 4.2.23: Examples of health effects due to weather and climate change

Event	Some Potential Damaging Health Effects
Warmer climate	• Can create conditions for spread of new vectors such as those for malaria, dengue, tick-borne encephalitis, and Lyme disease • Higher temperature shorten the development time of pathogens
Drought	• Less water for hygiene • Reduced food supplies cause malnutrition • Forest fires reduce air quality
Heat waves	• Heatstroke and increases in mortality from cardiovascular and respiratory diseases
Floods, landslides and windstorms	• Deaths and injuries • Disruptions to water-supply and sanitation systems and health care infrastructure • Post-traumatic stress disorders • New breeding sites for mosquitoes

2. Agriculture Sector

Among the technology options for agriculture sector in adapting to climate change are:

- Improve long term weather and short term climate forecasting capabilities
- Reduce runoff, improve water uptake and reduce wind erosion
- Improve irrigation and control soil erosion.
- Change farming practices to conserve soil moisture and nutrients, reduce runoff and control soil erosion
- Change timing of farming operations to adapt to new climatic conditions
- Use different crops or varieties to match changing water supply and temperature conditions,

- Improve biotechnology to produce new crops, examples- pest resistant crops, higher yield crops, crops that perform better under changing climatic conditions to cope with drought and heat stress.
- Improve water irrigation systems.
- More advanced forecasting and use of geographical information systems combining meteorological, climatic, hydrological and land use data.
- Better monitoring and assessment tool for natural hazard and water resources management.
- Greater awareness programmes to farmers on the potential impact of climatic changes.
- Improved support centres to build capacity of farmers to adapt to climatic changes.

Table 4.2.24: Examples of adaptation options for agriculture

Response Strategy	Some Adaptation Options
• Use different crops	• Carry out research on new varieties
• Change land topography to improve water uptake and reduce wind erosion	• Subdivide large fields • Maintain grass waterways • Roughen the land surface • Build windbreaks
• Improve water use and availability, control erosion	• Line canals with plastic films • Concentrate irrigation in periods of peak growth • Use drip irrigation
• Change farming practices to conserve soil moisture and nutrients, reduce run-off and control soil erosion	• Mulch stubble and straw • Rotate crops • Avoid monocropping • Use lower planting densities
• Change the timing of farm operations	• Advance sowing dates to offset moisture stress during warm periods

3. Coastal Sector

The technology options on the coastal sector follows the objectives as follows:

- Prevention of future major developments in coastal areas, conditional phase out programme for projects along the coastline.
- Increase adaptive responses through increasing elevation of buildings, better drainage systems and land use changes through modification of building and land use codes, protection of coastal eco-systems, strict enforcement of hazard areas
- Strengthening coastlines by better protective structures, dikes, floodwalls, levees, breakwaters, floodgates, and tidal barriers, salt water intrusion barriers

Table 4.2.25: Technologies for adaptation in coastal area

Protect	Retreat	Accommodate
• Hard Structures – dykes, Sea-walls, tidal barriers, detached breakwaters • Soft Structures – dune or wetland restoration or creation, beach nourishment • Indigenous options- walls or wood, stone or coconut leaf, afforestation	• Establishing set-back zones • Relocating threatened buildings • Phasing out development in exposed areas • Creating upland buffers • Rolling easements	• Early warning and evacuation systems • Hazard insurance • New agricultural practices, such as using salt-resistant crops • Improved drainage • Desalination systems

Table 4.2.26: Socio –economic impacts of climate change in coastal areas

Sector	More Frequent Floods	Erosion of Coast	Inundation by sea water	Rise in water table	Intrusion of salt-water	Changes in biological processes
Water resources	-	-	X	X	X	X
Agriculture	X	-	X	X	X	-
Human health	X	-	X	-	-	X
Fisheries	X	X	X	-	X	X
Tourism	X	X	X	-	-	X
Human settlements	X	X	X	X	-	-

4. Water Sector

The technological options for water sector:

- Population growth and increasing demand for quality water.
- Improve water resource management through better demand management and supply development. For example, the efficient water systems in the household through water efficient shower heads and leak proof taps and piping systems; increasing capacity of reservoirs; reducing losses to evaporation, seepage and leakage.
- Better legal and policy instruments such as water pricing.
- Greater awareness on the ecological and societal consequences of water shortages.

- Improving inter basin transfer of water.
- Potential use of wastewater.
- Potential desalination of seawater through membrane separation processes or thermal processes which are commercially available. However, it needs more energy efficient and inexpensive technology in the long run.
- Improve predictive capacities of stream flow in rivers using geographical information systems and combining remote sensing with on-site measurements and meteorological information.
- Increasing the reliability of regional climate projections and adaptation.
- Increasing water quality through pollution prevention and control, eg increase river flow so as to improve the rivers' capacity to dilute pollutant concentrations.
- Reduce the intrusion of salt water through building barriers across rivers, tune filter discharge of rivers to keep salt wedge at the river mouth in dynamic equilibrium, build sluices gate to allow for outflow but not inflow, switch to salt resistant crops or other activities less impacted by saline intrusion and develop more freshwater inlets further upstream.

Table 4.2.27: Examples of adaptation technologies for water resources

Use Category	Supply Side	Demand Side
Municipal or Domestic	• Increase reservoir capacity • Desalinate • Make Inter-basin transfers	• Use 'grey' water • Reduce leakage • Use non-water based sanitation • Enforce water standards
Industrial Cooling	• Use lower grade water	• Increase efficiency and recycling
Hydropower	• Increase reservoir capacity	• Increase turbine efficiency
Navigation	• Build weirs and locks	• Alter ship size and frequency of sailings
Pollution Control	• Enhance treatment works • Reuse and reclaim materials	• Reduce effluent volumes • Promote alternatives to chemicals
Flood Management	• Build reservoirs and levees • Protect and restore wetlands	• Improve flood warnings • Curb floodplain development
Agriculture- Rain Fed	• Improve soil conservation	• Use drought resistant crops
Agriculture- Irrigated	• Change tilling practices • Harvest rainwater	• Increase irrigation efficiency • Change irrigation water pricing

Source: adapted from

i. UNFCCC (2006) Technologies for Adaptation to Climate Change

ii. Richard J.K.Klein and Richard S.J. Tol (1997) –Adaptation to Climate Change: Options and Technologies and

iii. Smith (1997), Setting Priorities for Adaptation to Climate Change " Global Environmental Change"

4.3 Technological Intervention Towards Low Carbon Economy Pathways

4.3.1 Low Carbon Economy Pathways from Other Countries

As discussed in Section 4.2 there are various low carbon technologies available and under development globally. However, the development stages may be differed in some countries, for example wind technology is currently cost competitive against gas-fired power plant technologies in US, but in India wind technology may be technically but not financially viable against coal-fired power plants technologies. (World Development Report, 2010)

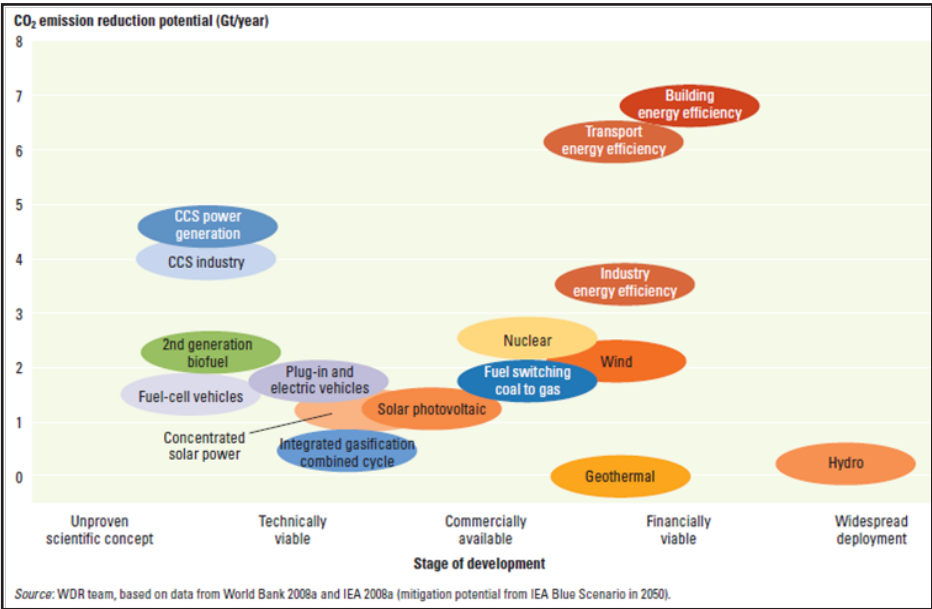


Figure 4.3.1: Stage of Development for Low-Carbon Technologies
Source: World Development Report, 2010

To understand the development of Low Carbon Economy (LCE) in other countries, the relevant reports from the following countries and cities were reviewed; European Union, Japan, Kyoto, Korea, Vietnam, Thailand, Shenzhen, China and Jilin City China.

4.3.1.1 Developed Countries

European Union

For European countries; the electricity grid in Europe will be able to integrate up to 35% renewable electricity in a seamless way and operate along the 'smart' principle that effectively matching supply and demand while another 14% of the EU energy mix will be from cost-competitive of sustainable bio-energy. For carbon capture and storage technologies, it will become cost competitive within a carbon pricing environment by 2020-2025 whilst existing nuclear technologies will continue to provide around 30% of EU electricity in the next decades. EU has targeted that First Generation-IV nuclear reactor prototypes will be in operation in 2020. By year 2020, 25 to 30 European cities will be at the forefront of the transition to a low carbon economy. All of these initiatives are estimated to cost about €58.5 - €71.5 billion. (**APPENDIX 4.2**).

Japan

Japan has several options for LCE that are segmented by sectors. For energy supply, improvement of carbon intensity can be done by changing fuel mix to low carbon energy sources such as natural gas, nuclear energy and renewable energy. In transportation, emission may reduce through improvement of energy and carbon intensity where they practice widespread use of motor-driven vehicle as electric vehicle and fuel-cell electric vehicle. The use of pedestrian friendly city design may reduce energy consumption and enable 40% of carbon reduction. For residential and commercial, they have used efficient heat pump air-conditioner, efficient water heater and efficient lighting equipment. While for industrial sector, Japan has implemented to produce and consume farm product in season. (**APPENDIX 4.3**).

Kyoto, Japan

Kyoto has targeted to reduce emission based on six actions. Those actions are introducing walkable city, Kyoto-style buildings and forest development, low carbon lifestyle, decarbonation of industry, comprehensive use of renewable energy and establishment of funding mechanism. The walkable city may reduce CO₂ emission in 2030 by 722KtCO₂ while Kyoto-style building and forest management may reduce emission about 50KtCO₂. The comprehensive use of renewable energy will be able to reduce CO₂ emission amount of 513KtCO₂. (**APPENDIX 4.4**).

Korea

There are three strategies and 10 policy directions in Korea's 5 years green growth plan towards LCE. The strategies include the measurement for climate change and securing energy independence by reducing carbon emissions, decreasing energy dependence and enhancing energy self-sufficient while supporting adaptation to climate change impacts. Other strategies applied in Korea are creation of new growth engines through development of green technologies as future growth engines, greening of industry, developing cutting-edge industries and setting up policy infrastructure for green growth. The last two strategies are improving quality of life and strengthening the status of the country. These strategies may be achieved by developing green city and green transportation, green revolution in lifestyle and enhancing global cooperation on green growth. (**APPENDIX 4.5**).

4.3.1.2 Developing Countries

Vietnam

Vietnam has five actions towards LCE where they have implemented convenient transportation, green building, energy efficiency improvement, fuel switch for industry and smart power plants. Focusing investment on road network development, building new and upgrading key national highways may contribute to 16% of total CO₂ emission reduction. Fuel shifting and natural energy utilization comprising biomass heating, solar heating, photovoltaic power and solar heater contributes to 39% and 48% of CO₂ emission respectively. Fuel uses in industry will be able to shift from high to low carbon intensity. As example, fuel shifting from coal and oil to natural gas. (**APPENDIX 4.6**).

Thailand

In Thailand several CO₂ emission reduction potential measures have been identified. For example in the residential sector, GHG mitigation is implemented through improving efficiency of electrical appliances. In commercial sector, the emission reduction is achieved based on optimization and efficient use of energy in buildings. It is reported that the industrial sector and transport sector through energy efficiency improvement and fuel switching will reduce GHG emissions by 122.5 MtCO₂ and 15.4 MtCO₂ respectively. (**APPENDIX 4.7**).

Shenzhen, China

In Shenzhen, it is targeted to reduce 20-30% energy of carbon content through developing nuclear energy, renewable energy, deploying Carbon Capture Storage (CCS), increasing natural gas use and natural gas import. Shenzhen has also facilitated low carbon industries and services development to promote their economic growth. They have developed new energy industries and manufacture high energy efficiency products by displacing low energy efficiency equipment with the higher efficiency, introducing low carbon transportation and running new energy vehicles like hybrid cars in order to slow energy consumption growth. (**APPENDIX 4.8**)

Jilin City, China

LCE option for Jilin City has been implemented based on industry such as steel industry, chemical industry, paper making, textile, non-ferrous metal, building, machinery, residential, services, transport and common use. Renewable energy option for Jilin City is from natural and mineral resources, excellent water resources for hydropower, wind resources, and biomass resources. Carbon productivity for Jilin City is equivalent to 58% improvement for carbon intensity in 2020. Achieving the indicator for carbon productivity in 2020 for Jilin City would result in 19% emissions lower than in the BAU scenario. (**APPENDIX 4.9**)

4.3.2 Options for Malaysia

Several potential options for Malaysia can be categorized into the following four areas as follows:

1. Reducing carbon content of energy resources
2. Energy efficiency and conservation for low carbon growth
3. Facilitating low carbon industries and services development to promote green growth
4. Low carbon alternatives for non-energy sectors.

Each area is explained in section 4.3.2.1 to section 4.3.2.4

4.3.2.1 Reducing Carbon Content of Energy Resources

The reduction of carbon content in the energy resources is crucial for achieving Low Carbon Economy Pathways. Since Malaysia is heavily dependent on fossil fuel, it has the immediate need to lower the amount of carbon release from fossil fuels. The available options such as deployment of Carbon Capture and Storage (CCS), nuclear energy, promoting of renewable energy and increasing of natural gas use are among other ways to do so. Table 4.3.1 below summarizes the options/initiatives for Malaysia. The options/initiatives are prioritised based on its relative ease of implementation.

Table 4.3.1: Options and initiatives for reducing carbon content in Malaysia

Options / Initiatives	Strategies	Major Barriers
i. Solar energy –PV & CSP* *Concentrating solar power	• PV Systems to enhance the energy yield and reduce costs • Integration of PV-generated electricity • Reduction of generation, operation and maintenance costs • Improvement of operational flexibility and energy dispatch ability • Improvement in the environmental and water-use footprint	• Limited policy framework • Insufficient funding or financing difficulties, currently depending on the limited FIT yearly quota • Legislating issues in connecting to national grid • High capital cost • Solar CSP require large acreage of land for installation
ii. Bio energy	• Production of ethanol and higher alcohols from ligno-cellulosic feedstock (agricultural and forest biomass – either residues or dedicated crops- and urban municipal solid waste) • Synthesis of hydrocarbons (e.g. diesel and jet fuel) through biological and/or chemical process from biomass containing carbohydrates. • The micro-organism (algae, bacteria)-based production of bio energy carriers (e.g. bio-oils) from CO2 and sunlight, and further upgrading into transportation fuels (e.g. bio-diesel and aviation fuels) • Electricity generation from biomass waste • BioCoal (Pelletization of biomass waste, i.e. EFB etc) • Biodiesel from non-food crops	• Fossil fuel subsidies causing non-level playing field for bio-energy • Opportunity cost for other users • Lack of experience and awareness in technology and management • Limited policy framework • High investment cost
iii. Expanding use of centralised (grid connected) renewable energy	• Expanding capacity to meet future needs based on strong RE resource base	• Legislating issues in connecting to national grid • Currently renewable energy sources is located quite a distance from the grid

table continues...

Options / Initiatives		Strategies	Major Barriers
iv. Decentralized generation from renewables		Rural electrification	- Legislating issues in connecting to national grid - Difficulties to maintain the installed systems due to its location - Lack of capacity buildings on O&M
v. Wind energy		- Low Speed Wind Turbine - New turbines and components to lower investment, operation and maintenance costs - Offshore technology with a focus on structures for large-scale turbines and deep waters (> 30 m). - Grid integration techniques for large-scale penetration of variable electricity supply. - Resource assessment and spatial planning to support wind energy deployment	- Low wind speed even in the east coast of Malaysia - Investment for the offshore technology is high. Estimated to be around USD 2,000 per KWh as in 2010 (Wind Technology Market Report, 2010)
vi. Nuclear Energy		- Design, construction and operation of a prototype sodium fast reactor (SFR) coupled to the grid - Design, construction and operation of a demonstrator (not coupled to the grid) of alternative technology, either gas or lead cooled fast reactor (GFR or LFR)	- Public acceptance on safety issues - High capital cost - Concerns on permanent waste disposal site
vii. Increasing natural gas use		Infrastructure: Regasification of LNG in Peninsular Malaysia, Trans-ASEAN Gas Pipeline	Low price of natural gas due to subsidies
viii. Carbon Capture and Storage (CCS)		- Improving power plant efficiency in fossil fuel power generation will help to compensate the energy usage by the CO₂ Capture process in CCS - R&D in the material used for pipelines and terminal storage installations.	- High cost in deploying the technology - Technology will be commercially viable in 20 years and beyond. - Concerns on possible leakage of stored CO₂ - Public acceptance on the safety of the technology

4.3.2.2 Energy Efficiency and Conservation for Low Carbon Growth

The options for efficient utilization and conservation of energy are considered as “low hanging fruits”. Various measures are available to achieve a low carbon growth with lower cost to the implementation agencies. The options such as displacing low energy efficiency (EE) equipment with high efficiency; high EE electric appliances, rolling out of smart meters, green travel, low carbon dietary; low carbon transportation-public traffic promotion, using new energy efficient vehicle – hybrid electric vehicles. Table 4.3.2 summarizes options for efficient utilization and conservation of energy in Malaysia. The options/initiatives are prioritised based on its relative ease of implementation.

Table 4.3.2: Options and initiatives for energy efficiency and conservation in Malaysia

Options / Initiatives	Strategies	Major Barriers
i. Energy Efficiency Improvement	- Used to convert the existing or low-efficiency device, equipment, motors or vehicles into "best available technology" models in all sectors - Developed and implement "Nation Strategic Programme on Energy Saving and Effective Use"	- Low tariff due to fossil fuel price subsidies - High upfront cost on changing to energy efficient equipments
ii. Green Building	- To raise awareness of building-related impacts and opportunities - To have more buildings to be certified as green building - To build more demonstration projects for green building	- Fuel price subsidies lack of funding - Lack of public consciousness on the benefit of green building - Low priority on building owners and cooperation on the need to conserve energy and environment - High cost for retrofitting existing building.
iii. Tackling energy inefficiency in SMEs	Reducing industry fuel costs, increasing competitiveness	- Low fuel prices due to subsidies. - Lack of awareness on importance of energy efficiency and conservation. - High initial upfront cost to invest on energy efficiency equipment.
iv. Improving efficiency of transport sector	- Increase investment towards more efficient public transportation sector - Bold policy to control and reduce the use of motor vehicles - Moving towards market pricing of fuel - Promote more efficient vehicles (eg Electric and Hybrid Vehicles) - Enhance implementation of policy towards the use of alternative fuel	- Low fossil fuel price due to subsidies - Lack of integration of current public mode of urban transport - Current subsidized price of gasoline does not encourage the shift towards public transport. - Mindset change on consumer preference to public transport.
v. Fuel switching for Industry	Fuel switch from coal and oil to natural gas	- Low price of gas - Moving towards becoming net importer of energy, thus susceptible to fluctuation of market price. - Current gas price is heavily subsidized.

table continues...

Options / Initiatives	Strategies	Major Barriers
vi. Efficient Power Systems	- Promoting cogeneration - Use of more efficient technologies for coal and gas power plant - Reducing transmission and distribution loss - Diversifying energy mix towards nuclear power plant	- High investment in efficient technology - Low energy price due to subsidy
vii. Smart Metering (Electricity Grid)	- Visualisation of consumption for consumers - Dynamic time of use tariffs and home automation technologies. - Solutions for smart metering infrastructure to unlock the potential of smart meters	- Legislation issues in connection to the grid - High investment cost
viii. Smart Cities	<i>Heating and Cooling</i> - Innovative and cost effective biomass, solar thermal and geothermal <i>Electricity</i> - Smart grids, allowing renewable generation, electric vehicles charging, storage, demand response and grid balancing. - Smart metering and energy management systems. - Smart appliances (ICT, domestic appliances), lighting (in particular solid state lighting for street and indoor), equipment (e.g. motor systems, water systems) <i>Transport</i> - Smart applications for ticketing, intelligent traffic management and congestion avoidance, demand management, travel information and communication, freight distribution, walking and cycling	- Legislation framework for the smart cities are not comprehensive - Legislation issues for connection to grid - High investment cost for infrastructure to move towards smart cities concept - For transportation sector, lack of integrated urban and rural planning of existing cities

4.3.2.3 Facilitating Low Carbon Industries and Services Development to Promote Green Growth

Apart from the physical technology, a services development is needed to ensure that the Low Carbon Economy pathways are achieved. The supporting services facilities are needed not only to facilitate but also to promote the ideas of sustainable development and provide some funding to ensure that the visions of Green Growth are achieved. Table 4.3.3 below provides initiatives to promote and facilitate the Low Carbon Economy Pathways. The options/initiatives are prioritised based on its relative ease of implementation.

Table 4.3.3: Facilitating low-carbon industries and service development options in Malaysia

Options / Initiatives	Strategies	Major Barriers
i. Feed in tariff (FiT)	- Promoting RE technologies – biomass(inclusive of municipal solid waste), biogas (inclusive of landfill/sewage), small hydro and solar photovoltaic. - Periodical revision of degression rates - Increasing funding or Feed in Tariff.	- Low quotas given to the industry players - Lack of funding - Insufficient funds for FiT in order to meet the demand.
ii. Facilitating low carbon industries and services development to promote green growth	- Facilitating carbon services-monitoring CO2 emissions , carbon auditing, carbon labelling, carbon trading, carbon finance, carbon insurance - Manufacturing high energy efficiency products –LED, PV-LED, smart grid products and smart meters - Promoting the energy efficiency improving services, eg ESCOs-Research and Development on Low-Carbon technologies for industries. - Technological innovation to enhance energy efficiency	- Reluctance of the industry players to go for green technology and growth - Low promotion and awareness programme for green growth - Lacking of sufficient expertise in the area. - Lacking of grants and supports to carry-out the science and technological innovation.

4.3.2.4 Low Carbon Alternatives for Non-Energy Sectors

Apart from energy sectors, non-energy sectors such as waste, agriculture and LULUCF contribute to a significant amount of carbon emission. Therefore, an option is also needed to ensure that low carbon growth is achieved. Table 4.3.4 below provides the options available for non-energy sectors. The options/initiatives are prioritised based on its relative ease of implementation.

Table 4.3.4: Low Carbon Alternatives for Non-Energy Sector

Options / Initiatives	Strategies	Major Barriers
i. Municipal solid waste management	• Increase recycling rate • Increase capture of landfill gas	• Cultural barriers on recycling efforts • High investment needed for increase capture of landfill gas • Insufficient policy framework
ii. Palm Oil Mill Effluent management	• Reduction of organic load by adopting anaerobic digestion method	• High investment needed • Insufficient policy framework.
iii. Improve livestock and cropland management	• Improve agriculture productivity and reduce land degradation	• High investment needed
iv. REDD+/Afforestation	• Reduce rate of forest conversion and degradation via REDD+ initiative • Protect forestry-dependent economy and efficient forest management • Stringent enforcement on policy to maintain 50% forest cover	• Different land jurisdiction for Peninsular Malaysia, Sabah and Sarawak

4.3.3 Current Policies and Programmes for Supporting Low Carbon Development

Currently, Malaysia has managed to implement various key policies and programs towards achieving the low carbon economy pathways. Among the initiatives taken are highlighted in section 4.3.3.1 to section 4.3.3.7.

4.3.3.1 Green Technology Policy

Malaysia is also a fast growing nation in Southeast Asia region. Presently, Malaysia is one of the signatories of Kyoto Protocol and a member of the G77 and other climate change associations. Malaysia has undergone a rapid industrialization process for the past 20 years and has taken various initiatives to bring huge investment to industrial sector and infrastructure development in the country. This indirectly creates a high demand for energy consumption locally and internationally (Malaysia Report, 2003). The rapid economic growth places a heavy demand for energy from fossil fuel and other energy resources to propel further economic growth in the country.

The introduction of Green Technology Policy shall be a driver to accelerate the national economy and promote sustainable development (PTM, 2009). The development of LCE is guided by National Green Technology Policy supported by 4 pillars as follows:

- i. Energy, under which the country would seek to attain energy independence and promote efficient utilization.
- ii. Environment, where it is committed to conserve and minimize the impact of the environment.
- iii. Economy, where it would seek to enhance the national economic development through the use of technology.
- iv. Social, where it would look into to improve the life quality for all.

4.3.3.2 Green Building Index

The Green Building Index (GBI) is Malaysia industry recognized green rating tool for buildings to promote sustainability in the built environment and raise awareness among Developers, Architects, Engineers, Planners, Designers, Contractors and the Public about environmental issues and our responsibility to the future generations.

The GBI rating tool provides an opportunity for developers and building owners to design and construct green, sustainable buildings that can provide energy savings, water savings, a healthier indoor environment, better connectivity to public transport and the adoption of recycling and greenery for their projects and reduce our impact on the environment. GBI certificate holders entitled to fiscal initiatives such as income tax and stamp duty exemptions equivalent to the additional capital expenditure to green their building.

4.3.3.3 Energy Efficiency and Conservation

Many energy efficiency initiatives have been carried out by the Government in the past with notable achievements. In order to strategize the efforts in addressing the issues of energy security, global warming and climate change, National Energy Efficiency Master Plan (NEEMP) has been proposed. The proposed NEEMP has set a target for a period of 10 years from 2012 focuses in three sectors identified namely Industrial, Commercial and Residential. Through effective implementation of the strategic actions in NEEMP, the total accumulated energy savings from these sectors is 79.8 TWh. This will enable the reduction of 59.16 MtCO₂.

Other efforts taken by the government in implementing energy efficiency (EE) are such as Electrical Appliance Labelling Programme, auditing and retrofitting existing buildings, phasing out of incandescent bulb usage in phases, and introduction of efficient light bulb (i.e., LED and CFL).

To ensure efficient energy management is practiced at all levels of society and in all social and economic activities, there must be greater understanding, support, co-operation and willingness from the government, industries, companies and individuals.

4.3.3.4 Solid Waste Management

Solid Waste Management (SWM) is regulated by the Solid Waste and Public Cleansing Management Act 2007 that was intended to shift the burden of solid waste management from municipal authorities to the federal government and promotes privatization of waste management. This Act controls solid waste generators and persons in possession of controlled solid waste where the waste is to be separated, handled and stored with licensing and approval system in place.

4.3.3.5 The Efficient Management of Electrical Energy Regulation

The purpose of this regulation is to promote efficient use of electrical energy through better planning and management for the industrial and commercial sector. The regulation requires that any installation with total electricity consumption of 3 million kWh or more over six (6) consecutive months is required to appoint an electrical energy manager and implement efficient electrical energy management. The regulation came into effect in 2008.

4.3.3.6 Green Technology Financing Scheme (GTFS)

The Green Technology Financing Scheme (GTFS) with a value of RM 1.5 billion was established by the Government in 2009 to promote investments in green technology; a sector that is envisaged to be one of the emerging drivers of economic growth for the country. This is a national initiative aimed at achieving a sustainable environment. The Participating Financial Institutions' (PFIs) role is critical in ensuring the success of the GTFS, which entails the financing of companies that supply and utilise green technology. Investment in Green Technology refers to products, equipment, or systems which satisfy the following:-

- Minimise the degradation of the environment;
- Have zero or low green house gas (GHG) emission;
- Safe for use and promote healthy and improved environment for all forms of life;
- Conserve the use of energy and natural resources; or
- Promote the use of renewable resources.

As of February 2012 the balance for GTFS amounts to RM 774.6 million (MEGTW, 2012). In recent 2013 budget, an additional of RM 2 billion has been provided to encourage companies especially SMEs to move towards green technology.

4.3.3.7 Bio-Fuel Policy and Programme

National Biofuel Policy 2006 is primarily aimed at reducing the country's dependence on depleting fossil fuels. The policy aims to promote the demand for palm oil as an alternative source of bio-fuel.

The policy was underpinned by five strategic thrusts as follows:

- Thrust 1: Bio-fuel for Transport
- Thrust 2: Bio-fuel for Industry
- Thrust 3: Bio-fuel for Technology
- Thrust 4: Bio-fuel for Export
- Thrust 5: Bio-fuel for Cleaner Environment

Biodiesel is included in the list of products / activities that are encouraged under the Promotion of Investments Act 1986. Biodiesel projects are therefore eligible to be considered for Pioneer Status or Investment Tax Allowance.

Other Environmental and Energy Policies relating to Low Carbon Economy pathways are summarized in APPENDIX 4.10.

4.4 Recommended Technological Interventions Towards Low Carbon Economy Pathways

The CO₂ mitigation analysis has been conducted concurrently with this report that identifies the relevant measures and initiatives required to achieve the targeted 40% carbon emission intensity reduction by 2020. The strategic options together with technologies are summarized in this section following the discussions in the previous sections.

4.4.1 Reducing Carbon Content

Strategy	Short-Term	Medium term	Long Term
POWER SECTOR			
Developing centralised renewable energy, e.g. Solar PV, biomass, mini hydro, biogas, etc	6% of total maximum demand in 2015	11% of total maximum demand in 2020	17% of total maximum demand in 2030
Other low carbon electricity			Supplying low carbon electricity by nuclear power and Carbon Capture and Storage (CCS), Advanced Coal Technologies, Clean Coal Technology
TRANSPORT SECTOR			
Increasing use of alternate fuels/renewable and cleaner source of energy	1. Mandatory use of bio- fuels/alternate fuels 2. Tax incentives	1. Investment in CNG infrastructure 2. Investment in R&D, e.g. hydrogen fuel cells	1. Investment in infrastructure of electric vehicles 2. Investment in hydrogen fuel cells infrastructure 3. Improve plant mix for electricity generation in Malaysia

Note: Short term (2013- 2015); Medium term (2016-2020); Long term (beyond 2020)

4.4.2 Energy Efficiency and Conservation for Low Carbon Growth

Strategy	Short-Term	Medium term	Long Term
TRANSPORT SECTOR			
Increasing share of rail in passenger and freight movement	1. Procurement of locomotives, wagons 2. Analyse commodity movement for right marketing strategies	1. Enhancing capacity and expansion of rail network	1. Identify corridors with the high density and conduct feasibility study for high speed rail
Reducing the demand for personalised modes of transport and increasing the share of public transport	1. Capital subsidy for buses 2. Improve connectivity for unserved area 3. Car Pooling 4. Taxes and Duties on Vehicles 5. Congestion pricing and tolls 6. Vehicle Quota System 7. Park and Ride facilities 8. Fuel pricing 9. Further increase capacity of LRT, Monorail	1. Expand the coverage of rail-based mode of transport within the central business district and suburb	1. Improving planning of cities so as to reduce demand for transport
Improving the technology/efficiency of vehicles and emission standards	1. Fuel economy standards 2. Tightening of Emission Standards	1. R&D activities improving efficiency of vehicles 2. Labelling of vehicles	1. Improvement in Vehicle Technology
INDUSTRIAL SECTOR			
Enhancing energy Efficiency in the Industrial Sector	1. Energy audits 2. Capacity building 3. Improve house-keeping	1. Production of blended cements 2. Transformation of the industrial sector towards higher value add activities 3. Replace inefficient electric motors	1. Promote cogeneration in industrial facilities 2. Cleaner technologies for SMEs

table continues...

Strategy	Short-Term	Medium term	Long Term
RESIDENTIAL AND COMMERCIAL SECTOR			
Enhancing Energy Efficiency in the Residential and Commercial Sector	1. Further implementation of GBI 2. Energy managers for each commercial establishment 3. Mandatory programme under standard MS 1525:2007 – Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings 4. Include more appliances under the current Equipment Labelling programme 5. Monetary incentives for residential sector to undertake energy efficiency measures 6. Education on Energy Efficiency 7. Phasing out incandescent light bulb.	1. Provide incentives for GBI certified buildings 2. Reduction in electricity subsidies 3. 'Consume more, pay more' strategy to be adopted 4. Decouple pricing with social welfare 5. Introduction of Minimum Energy Performance Standard (MEPs)	1. Decentralised energy system, including solar energy 2. LED and solar street lighting 3. Mandatory reporting on energy efficiency/ audits for both residential and commercial sectors 4. Low Carbon Cities

Note: Short term (2013- 2015); Medium term (2016-2020); Long term (beyond 2020)

4.4.3 Facilitating Low Carbon Industries and Services Development to Promote Green Growth

Strategy	Short-Term	Medium term	Long Term
Facilitating low carbon industries and services development to promote economic growth	1. Promoting energy efficiency improving services 2. Financial Incentives	1. Facilitating carbon services-monitoring CO₂ emissions , carbon auditing, carbon labelling, carbon trading, carbon finance, carbon insurance 2. Financial Incentives	1. Manufacturing high energy efficiency products –LED,PV-LED, smart grid products and smart meters 2. Financial Incentives

Note: Short term (2013- 2015); Medium term (2016-2020); Long term (beyond 2020)

4.4.4 Low Carbon Alternative for Non-Energy Sectors

Strategy	Short-Term	Medium term	Long Term
WASTE SECTOR			
Municipal solid waste management	1. Increasing the recycling rate to 10% 2. Closing all the landfills which are not level 4 with provision of LFG capture and flaring 3. Achieve capture of 10% landfill gas	1. Increasing the recycling rate to 25% 2. Closing all the landfills which are not level 4 with provision of LFG capture and flaring 3. Achieve capture of 25% landfill gas 4. Decentralized/centralized development of anaerobic digestion/incinerator system for treatment of food waste and capture of biogas 5. Move progressively towards diversion of organic waste from landfills	1. Increasing the recycling rate to 40% 2. Achieve capture of 50% landfill gas
Palm Oil Mill Effluent Management	1. Reduction in organic load by 25% by adopting anaerobic digestion method	1. Reduction in organic load by 50% by adopting anaerobic digestion method	1. Reduction in organic load by 75% by adopting anaerobic digestion method
AGRICULTURE SECTOR			
Sustainable Farming System	1. Improved crop management practices (including water efficiency management) 2. Use of biofertilizers and biopesticides 3. Increase cropping cycles, especially in irrigated paddy areas 4. Initiate research on animal feed 5. Initiate research on developing better plant varieties, both by conventional and biotechnological tools 6. Initiate research on farm machinery to further reduce labour requirements in the field 7. Initiate research on livestock feed	1. Large scale adaptation of cleaner and more sustainable practices for agriculture 2. Establishment of commercial biofertilizers and biopesticides units 3. Adaptation of practices for improving breed of livestock 4. Ensuring availability of improved feed	1. Adaptation of crop developing varieties which are: • high yield, • varieties that utilizes resources (water and nutrients) more efficiently • Large scale adaptation of improved varieties of livestock and improved feed • Greater degree of farm mechanization • Adopting multiple cropping pattern

Note: Short term (2013- 2015); Medium term (2016-2020); Long term (beyond 2020)

4.5 Priorities for Low Carbon Investment

The priorities for Low Carbon Investment based on the GHG abatement cost are discussed in this section.

4.5.1 GHG Abatement Cost

The cost curve below (Figure 4.5.1) depicts the range of emission reduction actions that are possible with technologies that either are available today or are highly likely to be available by 2020. The cost of abatement is calculated from a societal perspective ¹⁵⁸ (i.e. excluding transaction cost, information and communication cost, subsidies or explicit costs, taxes, etc), which is useful to allow comparisons between opportunities and costs across countries.

The following Figure 4.5.1 shows several opportunities for reducing emissions at a relatively modest cost. The lowest overall abatement cost will be from the Residential and Commercial at a negative abatement cost of RM484.45 per tCO₂ eq., while the highest overall abatement cost is from power sector with RM113.24 per tCO₂ eq.

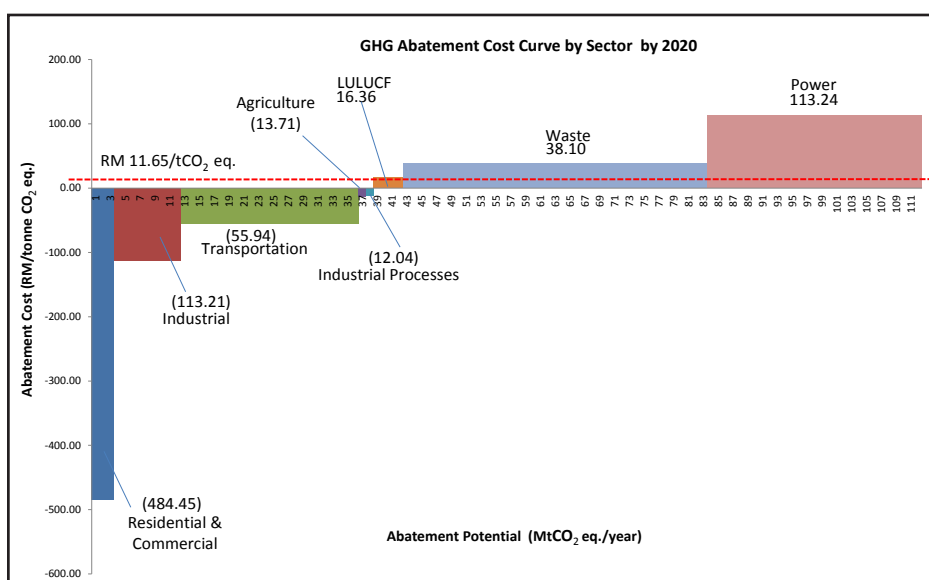


Figure 4.5.1: GHG abatement cost curve by sectors by 2020

¹⁵⁸ Abatement cost includes the annualized repayments for capital repayments or capital expenditure and operating expenditure. The abatement cost therefore considers the cost of project to install and operate the low carbon emission technology. It also covers the changes in allocation of resources rather than using alternative technology e.g. abatement levers developed using opportunity or replacement costs in LULUCF for deforestation initiatives.

4.5.2 Sectoral Abatement Cost

4.5.2.1 Power Sector

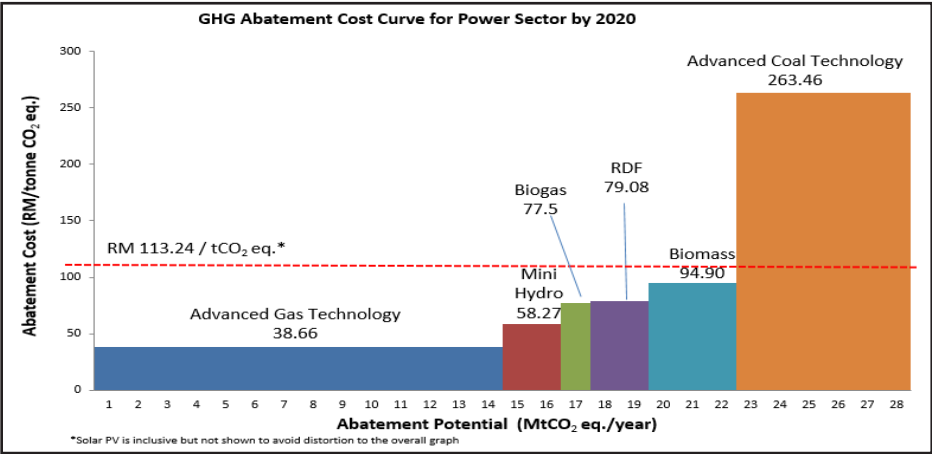


Figure 4.5.2: GHG abatement cost curve for power sector by 2020

The power sector is at an advantageous situation where it could tap the tremendous potential of renewable energy and alternative energy resources of supply. However, abatement cost of renewable energy-based power generation is the most expensive option at an average abatement cost of RM113.24 per tCO₂ eq. On the other hand, the costs of abatement for advance gas technology are estimated to be RM38.66 per tCO₂ eq.

4.5.2.2 Residential and Commercial

The potential reduction exists in the residential and commercial sector across five mitigation levers: replacement of incandescent bulb, building energy audit, raising air-conditioner temperature, energy efficient refrigerator, replacing T8 with T5 (T5 is a high efficiency lamps as compared to conventional T8 lamps. Power rating of T5 is 28W, while that of T8 is 40W. In terms of lifespan, T5 has 20,000 hours and T8 has 10,000 hours) in government buildings. While all of the opportunities are available at a negative abatement cost, implementing most of these levers will require upfront investment in related sectors as seen in Figure 4.5.3.

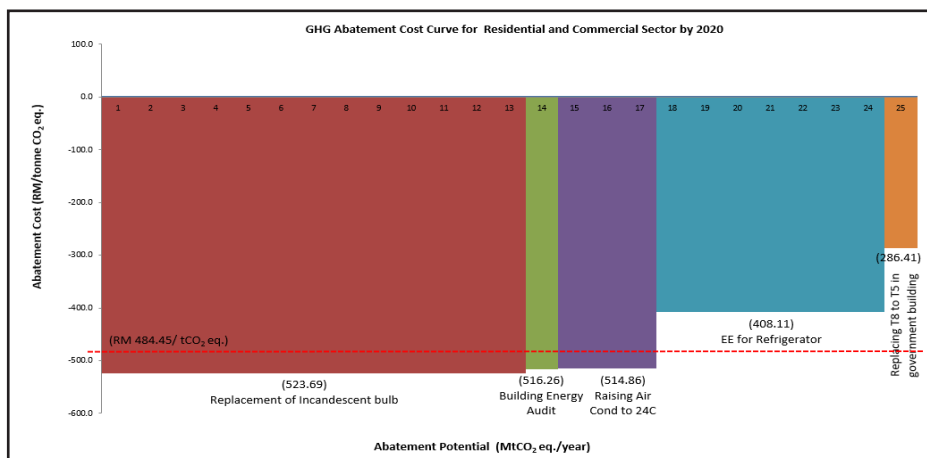


Figure 4.5.3: GHG abatement cost curve for residential and commercial sector by 2020

4.5.2.3 Transport Sector

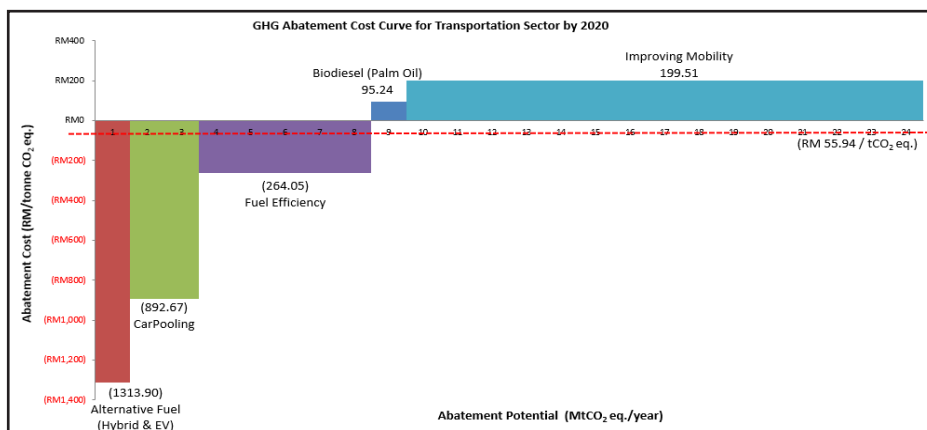


Figure 4.5.4: GHG abatement cost curve for transportation sector by 2020

The potential reduction exists in transport sector across five mitigation levers: improving mobility; moving from conventional vehicles to hybrid and electric vehicle; adoption of biodiesel from palm oil, improving fuel efficiency and car pooling.

Improving mobility represent the largest emission reduction at a cost of RM199.51 per tCO₂ eq. Fuel efficiency improvement represents the second largest opportunity at a relatively attractive option at a negative cost of RM264.05 per tCO₂ eq. Car pooling emission reduction is estimated to have a negative abatement cost of RM892.67 per tCO₂ eq. Shifting from conventional powered vehicle towards hybrid and electric vehicles represents minimal emission reduction, however, this option represents the most attractive option at a cost of -RM1,313.94 per tCO₂ eq. The potential reduction from the adoption of biodiesel from palm oil will have an abatement cost of RM95.24 per tCO₂ eq.

While a significant portion of the opportunity is available at a negative abatement cost, implementing most of these levers will require upfront investment in vehicles and infrastructure in related sectors.

4.5.2.4 Industrial Sector and Industrial Processes

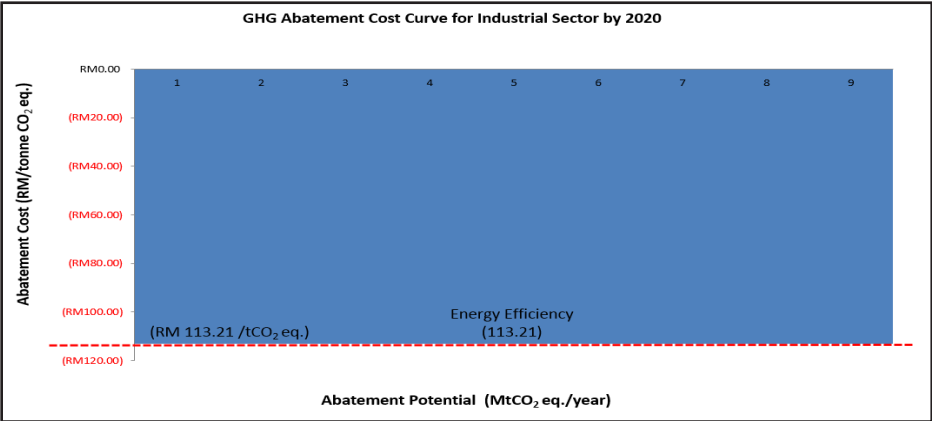


Figure 4.5.5: GHG abatement cost curve for industrial sector by 2020

Industrial sector in Malaysia indicates that there are limited GHG reduction strategies introduced by the government to reduce carbon emission intensity. The potential mitigation option that has been identified by the government is the application of demand side management which implies the promotion of energy efficient equipments, introduction of alternative products such as waste heat recovery and the use of waste-derived fuels in the industrial sector and industrial processes. However, greater efforts are needed in the form of a more rigorous imposition of energy audits, energy efficiency and efficient utilisation of better technologies. At the moment, energy efficiency is voluntary in Malaysia and most of the firms have an option whether to embark on the initiatives or not. Given the report by MIEEP and the audit, the estimated average abatement cost of the sector is RM113.21 per tCO₂ eq.

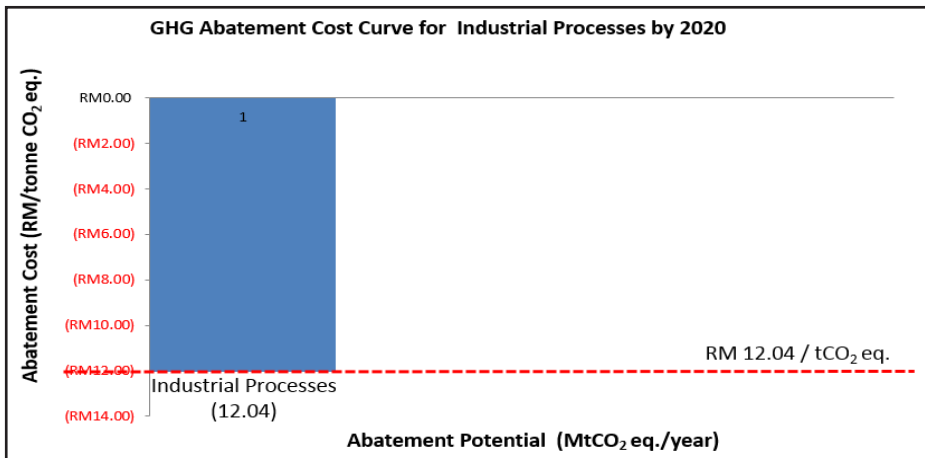


Figure 4.5.6: GHG abatement cost curve for industrial processes sector by 2020

The potential mitigation option for Industrial Processes that have been identified are the application of demand side management which includes the promotion of energy efficient equipments, introduction of alternative products such as waste heat recovery and the use of waste-derived fuels in the industrial sector and industrial processes. One of the GHG reduction strategies for cement product is to change the blend of raw material mix in cement production with additive such as fly ash, gypsum, and slag to reduce emission due to calcination process. Blending also reduces energy-related emission in the clinker production. The average abatement cost of the initiatives in the sector is estimated to be RM12.04 per tCO₂ eq.

4.5.2.5 Agriculture

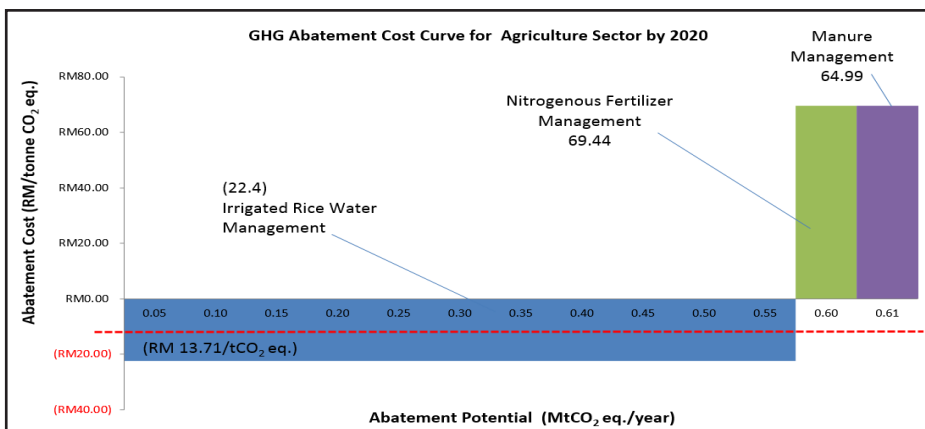


Figure 4.5.7: GHG abatement cost curve for agriculture sector by 2020

Opportunities for low carbon development in agriculture and forestry are also abound in rural areas. Greenhouse gas emissions savings could be achieved through changes in agricultural and livestock production methods. Irrigated rice water management is estimated to have a negative average abatement cost of -RM22.4 per tCO₂ eq¹⁵⁹ ; nitrogenous fertilizer management and manure management are estimated to have an average abatements cost of RM69.44 per tCO₂ eq¹⁶⁰ .

4.5.2.6 Waste

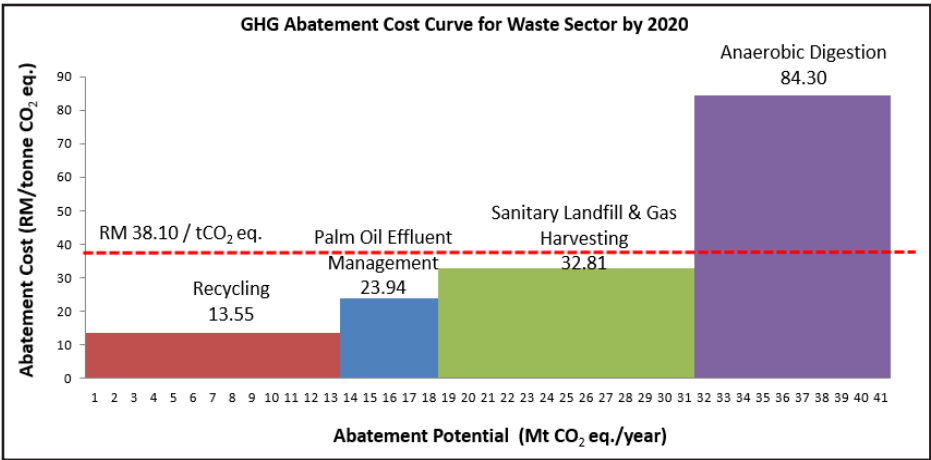


Figure 4.5.8: GHG abatement cost curve for waste sector by 2020

The potential reduction exists in the waste sector across four mitigation levers: recycling, palm oil effluent management, sanitary landfill & gas harvesting and raising anaerobic digestion. Anaerobic digestion initiative is estimated to have the highest average abatement cost at RM84.30 per tCO₂ eq, while recycling initiative is estimated to have the lowest average abatement cost at RM13.55 per tCO₂ eq.

¹⁵⁹ Indonesia’s Greenhouse Gas Abatement Cost Curve (August 2010) estimated that the GHG average abatement cost is –USD7per tCO₂ eq.

¹⁶⁰ Indonesia’s Greenhouse Gas Abatement Cost Curve (August 2010) estimated that the GHG average abatement cost is USD21.7 per tCO₂ eq.

4.5.2.7 Land Use, Land Use Change and Forestry (LULUCF)

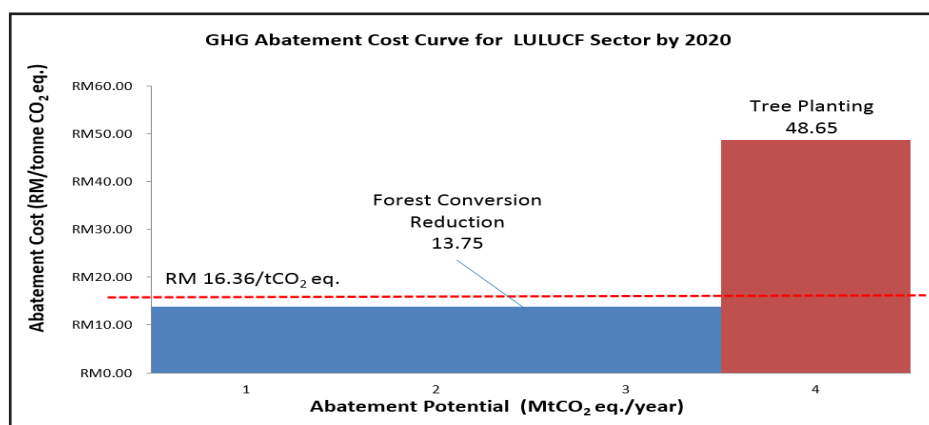


Figure 4.5.9: GHG abatement cost curve for LULUCF sector by 2020

The potential reduction exists in the 2-mitigation level, Tree planting and forest conversion reduction. The forest conversion reduction has an estimated of RM13.75 per tCO₂ eq while the tree planting is estimated to incur RM48.65 per tCO₂ eq.

4.6 Conclusion and Way Forward

A critical next step would entail a process of translating identified low carbon options into well-defined implementation plans for the successful transfer of the technology (hard or soft) to achieve a low carbon economy pathways. The important components of this implementation process include the involvement of appropriate and effective stakeholders within the framework for the technology transfer. Other issues that will have to be addressed by the stakeholders are the availability of financial and human resources for transfer of acquiring the technology, a conducive environment for the smooth flow of technology to the final recipients and users. While elaborating the different steps of the implementation plan for the transfer of a technology, it will be important to identify capacity-building needs and other barriers that will have to be overcome. The eventual outcome may be the preparation of a project document for funding purposes for technologies requiring heavy investments.

As there is no single recipe for the transfer of different technologies, it is imperative to draw up an implementation plan that will accommodate all the prioritized technologies while paying due attention to the specific nature of the various options. Such an action will lead to the identification of more precise steps, barriers and capacity-building needs, as well as other activities that may be required, such as raising awareness and communication programmes. R&D partnerships are likely to be the key vehicle for technologies to be transferred. Many of the technologies which have been prioritised fall under the policies of various government departments, and the agencies that require their commitment to enhance the execution of Low Carbon Growth policies.

To achieve low-carbon economy pathways, there is a need for an integrated policy for sustainable development based on the sustainable low-carbon policies for all key socio-economic sectors (i.e., agriculture, industrial, transport, energy and water resources, etc). This requires better coordination and integration of the sustainable low-carbon policies for all key socio-economic sectors. It is envisaged that NRE can play a key role in the implementation of the low carbon economy pathways.

For the **power sector**, technology development and finance and investment as power demands would continue to increase rapidly, and changes to super-critical rather than sub-critical coal based technologies in the power sector can be brought in the short and medium term. While in the **transport sector**, there is a need to direct investment towards enhancing public transport and introducing legislation frameworks that facilitate greater efficiency in transport. An integrated urban and regional planning for the transportation sector could also be an effective option for reducing GHG emissions.

As far as the **residential and commercial sector** is concerned, the institutions need to play an important role in ensuring that the right kind of policy environment is created to enable the technology changes through especially for energy efficiency. In the industrial and industrial processes, research and development in the long run are required for the institutional set-up to be strengthened such that the sector is at par with global standards.

For the **agricultural sector**, R&D activities along with technology development are important in the medium and long term to improve practices such as livestock and manure managements. However, for the **waste sector**, it has a large potential for emissions reductions. Appropriate efforts have been directed towards mobilizing investments towards scaling up recycling and immediate attention is being paid to innovative models for addressing emissions from waste through the capture of biogas and anaerobic digestion technologies.

Further study is necessary to evaluate the social and environmental impacts of all the proposed options using the life cycle assessment methodology. It is necessary to consider the potential social and environmental costs (i.e., the externalities) for each of the proposed options. The exercise would enable a ranking of priority options based on cost-effectiveness and sustainability.

In order to achieve the low carbon society, proper policy and fiscal reforms are essential to facilitate the country's transition towards a low carbon economy. The policy and fiscal reforms may include among others, reform of energy pricing, subsidies and fiscal incentives to promote investment in green sectors, and the creation of a national carbon market.

Each of the relevant stakeholders (ministries, departments, agencies, etc) can further explore the recommended strategic options to develop appropriate policies and programmes in achieving Low Carbon Economy pathways for the country with the right energy mix in order to ensure sustainable development and security of the energy supply to meet the increasing demand, efficient waste management through new technologies, improvement of yield in agriculture and sustainable farming practices.

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APPENDIX 3.1

Emission Reduction Potential by Sector (MtCO₂ eq.) using NC2 reporting methodology

Sector	2005	2020		2030	
		BAU	AMB	BAU	AMB
Energy					
Electricity	57.5	73.7	65.7	105.2	70.97
Transport	45.3	88.7	70.5	125.3	80.5
Industrial	35.5	35.5	31.5	49.2	40.9
Residential & Commercial	4.3	9.2	8.1	18	12.3
Others*	61.8	89.8	75.2	129.1	88.7
Total Energy	204.4	296.9	250.5	426.8	293.4
Industrial processes	15.6	22.3	21.4	33.8	30.2
Agriculture	6.6	7.2	5.8	8.3	6.7
Waste	27.4	46.6	14.7	57.3	17.7
(a) Total excluding LULUCF emissions	253.9	372.98	292.32	526.24	347.96
(b) LULUCF (emissions)	25.3	32.66	26.13	28.04	22.43
(c) Total Emissions = (a) + (b)	279.2	405.64	318.45	554.28	370.39
(d) Sink	240.5	431.8	431.8	409.0	409.0
Net Total Emission after subtracting sink (c – d)	38.7	(26.16)	(113.35)	145.28	(38.61)
GDP (RM million)	449,250	961,214	961,214	1,463,191	1,463,191
Emission Intensity (kg CO ₂ /RM)	0.621	0.422	0.33	.38	.25
Reduction in Emission Intensity from 2005 level (%)		32%	47%	39%	59%

*Others include emissions from Energy industries such as fugitive emissions, manufacture of solid fuel, petroleum refining, etc.

APPENDIX 3.2

Policies and Programme in Energy Sector of Malaysia

Name	Type of Intervention: Policy/ Legislation/ Programme	Scope: Level- National/ State/ Local Body	Start/ End Date (Status)	Method/ Institution(s) Responsible for Implementation	Objectives/ Main Provisions/ Key Emphasis	Progress/ Achievements	Gaps/ Issues	Further Action
The National Petroleum Policy (1975)	Policy	National	1975		Introduced to ensure optimal use of petroleum resources and regulation of ownership, management and operation, and economic, social, and environmental safeguards in the exploitation of petroleum due to fast growing petroleum industry in Malaysia.	Formation of Petroleum Nasional Berhad (PETRONAS) in 17 August 1974	Discovery of oil	
National Energy Policy (1979)	Policy	National	1979 (In Force)	Ministry of Energy, Telecommunication & Post	Formulated with broad guidelines on long-term energy objectives and strategies to ensure efficient, secure and environmentally sustainable supplies of energy. It has Three main objectives: - Supply objective: To ensure the provision of adequate, secure, and cost-effective energy supplies through developing indigenous energy resources both non-renewable and renewable energy resources using the least cost options and diversification of supply sources both from within and outside the country - Utilization objective: To promote the efficient utilization of energy and to discourage wasteful and non-productive patterns of energy consumption - Environment objective: To minimize the negative impacts of energy production, transportation, conversion, utilization and consumption on the environment.		Dependency to oil as electricity generation	

table continues...

Name	Type of intervention: Policy/ Legislation/ Programme	Scope: Level- National/ State/ Local Body	Start/ End Date (Status)	Method/ Institution(s) Responsible for Implementation	Objectives/ Main Provisions/ Key Emphasis	Progress/ Achievements	Gaps/ Issues	Further Action
National Depletion Policy (1980)	Policy	National	1980 (In Force)		Introduced to safeguard against over exploitation of oil and gas reserves. Thus, it is production control policy			
Four Fuel Diversification Policy (1981)	Policy	National	1981 (In Force)		Fuel diversification was designed to avoid over-dependence on oil as main energy supply and aimed at placing increased emphasis on gas, hydro and coal in the energy mix			
Electricity Supply Act 1990 (Amended) 2001 or Act A1116	Legislation	National	1990 (In Force)	Ministry of Energy, Communications and Multimedia	Regulates the licensing of electricity generation, transmission and distribution Provisions on the efficient use of electricity - Section 23A: The Minister may, from time to time, prescribe the standards, specifications, practices and measures to be adopted and any other matters in regard to the efficient use of electricity. - Section 23B: No person shall use or operate any installation unless the installation meets such requirements as may be prescribed in regard to the efficient use of electricity. - Section 23C: No person shall manufacture, import, sell or offer for sale or lease any equipment unless the equipment meets such requirements as may be prescribed in regard to the efficient use of electricity			

table continues...

Name	Type of intervention: Policy/Legislation/Programme	Scope: Level-National/State/Local Body	Start/End Date (Status)	Method/Institution(s) Responsible for Implementation	Objectives/ Main Provisions/ Key Emphasis	Progress/ Achievements	Caps/ Issues	Further Action
Five-Fuel Policy (2001)	Policy	National	2001 (In Force)	Ministry of Energy, Communications and Multimedia	Introduced in recognition of the potential of biomass, biogas, municipal waste, solar and mini hydro as potential renewable energy resources for electricity generation	8th Malaysia Plan (2001-2005): targeted to have 5% or 600 MW of grid-connected electricity capacity from renewable energy in fuel mix by 2005 9th Malaysia Plan (2006-2007): targeted RE capacity to be connected to power grid utility has been revised to 1.8% fuel mix or 350 MW (300 MW in Peninsular Malaysia and 50 MW in Sabah) - Government initiatives and incentives to support RE consist of: - Small Renewable Energy Programs (SREP) - Biomass-based Power Generation and Co-generation (BIOGEN Project) with cooperation of United Nation Development Program (UNDP) and Global Environment Fund (GEF). - Malaysia Building Integrated Photovoltaic Technology Application Project (MBIPV) with UNDP-GEF - Fiscal incentives to promote RE	- The policy does not emphasize utilization of wind energy and geothermal. - Sabah has 67 MW of geothermal energy potential - As of 2010, out of 17 projects implemented, only 10 projects under operation consist of 65.1 MW out of 116.4 MW and about 19% of target set under 9MP - Revised target under 9MP excluding RE implementation in Sarawak - The adjusted electricity tariff for biomass and biogas projects (SREP) to 21 sen / kWh effectively in August 2007 not include hydro & solar - As of April 2009, 46.2 MW and 500 kW power plants are grid-connected and total of 700MW off-grid electricity has been produced by private oil palm millers - Wind pattern & velocity limit the application to only low wind speed for electricity production	- Renewable Energy Act implemented by October 1, 2011 with the introduction of Feed-in-Tariff (FIT) mechanism. - The study on geothermal potential in Sabah is in the early stage and the second phase study on isotope study will be conducted under 10 Malaysia Plan (2011-2015) to achieve more credible results

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Name	Type of Intervention: Policy/ Legislation/ Programme	Scope: Level- National/ State/ Local Body	Start/ End Date (Status)	Method/ Institution(s) Responsible for Implementation	Objectives/ Main Provisions/ Key Emphasis	Progress/ Achievements	Gaps/ Issues	Further Action
Energy Commission Act (2001) (Amendment 2009)	Legislation	National	2001 (In Force)	Energy Commission	- The Energy Commission (or Suruhanjaya Tenaga) was established: - To provide technical and performance regulation for the electricity and piped gas supply industries, - To advise the government on matters relating to electricity and piped gas supply including energy efficiency and renewable energy issues.		- not reservoir of geothermal energy potential located under Sabah National Park in which a protected area - Renewable Energy Power Purchase Agreement (REPPA) selling price agreed upon by the National Power Utility (TNB) for all RE grid-connected projects ranged from 14-17 sen/kWh does not seem to provide high enough rate of return to attract investors or project developers given the size of the project under SREP - Regulatory barriers: - lower priority given by Malaysian enterprises to RE - lack of functioning institutional network on RE	

table continues...

Name	Type of intervention: Policy/ Legislation/ Programme	Scope: Level- National/ State/ Local/ Body	Start/ End Date (Status)	Method/ Institution(s) Responsible for Implementation	Objectives/ Main Provisions/ Key Emphasis	Progress/ Achievements	Gaps/ Issues	Further Action
The National Policy on the Environment 2002	Policy	National	2002 (In Force)	Ministry of Natural Resources and Environment	- The objectives of the policy: 1. A clean, safe healthy and productive environment for present and future generations 2. Conservation of the country's unique and diverse cultural and natural heritage with effective participation from all sectors of the society 3. Sustainable lifestyles and patterns of consumption and production - Aims at continued economic, social and cultural progress of Malaysia and enhancement of the quality of life of its people through environmentally sound and sustainable development			
National Biofuel Policy (2006)	Policy	National	2006 (In Force)	Kementerian Perusahaan Perladangan dan Komoditi (KPPK)	- Supports the five fuels diversification policy. - Aimed at reducing the country's dependence on depleting fossil fuels & promoting the demand for palm oil. - Five key thrusts: transport, industry, technologies, export and cleaner environment. - Highlights: - Producing a biodiesel fuel blend of 5% processed palm oil with 95% petroleum diesel - Encouraging the use of biofuel by giving incentives for providing biodiesel pumps at fuelling stations - Establishing industry standard for biodiesel quality under Standards and Industrial Research Institute of Malaysia (SIRIM) - Setting up of a palm oil biodiesel plant	B5 fuelling station started to operate in June 2011 & located at Putrajaya. The Central Region implementation of the B5 programme continues in stages with Malacca in 1 July 2011 and in Negeri Sembilan in 6 August 2011.	- The first implementation of B5 fuelling station in Malaysia comes after 5 years the policy was introduced - The processing of biodiesel is costlier than that of normal diesel but that cost will now be absorbed by the Government	By 1 October 2011, implementation will have stretched to encompass fuel stations in Negeri Sembilan, Kuala Lumpur and Selangor at 1150 available petrol stations. Initial implementation of B5 usage will only cover land transport, but by 1 November 2011, the usage of B5 will extend to industries and deep-sea fishing

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Name	Type of Intervention: Policy/ Legislation/ Programme	Scope: Level- National/ State/ Local Body	Start/ End Date (Status)	Method/ Institution(s) Responsible for Implementation	Objectives/ Main Provisions/ Key Emphasis	Progress/ Achievements	Gaps/ Issues	Further Action
National Green Technology Policy (2009)	Policy	National	2009 (In Force)	MEGTW	• To reduce the energy usage rate and at the same time increase economic growth • To facilitate the growth of the green technology industry and enhance its contribution to the national economy • To increase national capability and capacity for innovation in green technology development and enhance Malaysia's competitiveness in green technology in the global arena • To ensure sustainable development and conserve the environment for future generations • To enhance public education and awareness on green technology and encourage its widespread use	• Restructuring of Malaysia Energy Centre (PTM) as The National Green Technology Centre (PTHN) • Green Technology Financing Scheme (GTFS) • Green Procurement and Labeling for GT • Promotion and Public Awareness on GT • International Conference and Exhibition on Green Technology • Green Township (Putrajaya and Cyberjaya) • Saving 10% of Energy and Water Usage in Government Building in Putrajaya		

table continues...

Name	Type of intervention: Policy/ Legislation/ Programme	Scope: Level- National/ State/ Local Body	Start/ End Date (Status)	Method/ Institution(s) Responsible for Implementation	Objectives/ Main Provisions/ Key Emphasis	Progress/ Achievements	Gaps/ Issues	Further Action
National Policy on Climate Change (2009)	Policy	National	2009 (In Force)	Ministry of Natural Resources and Environment	• Mainstreaming climate change through wise management of resources and enhanced environmental conservation resulting in strengthened economic competitiveness and improved quality of life; • Integration of responses into national policies, plans and programmes to strengthen the resilience of development from arising and potential impacts of climate change; • Strengthening of institutional and implementation capacity to better harness opportunities to reduce negative impacts of climate change. • Consolidation of the energy policy incorporating management practices that enhances Renewable Energy (RE) and Energy Efficiency (EE) • Empowering local communities in basic RE maintenance, especially in rural electrification including mini and micro hydroelectric schemes.			

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Name	Type of intervention : Policy/ Legislation/ Programme	Scope: Level- National/ State/ Local Body	Start/ End Date (Status)	Method/ Institution(s) Responsible for Implementation	Objectives/ Main Provisions/ Key Emphasis	Progress/ Achievements	Gaps/ Issues	Further Action
					- Identifying and recommending options towards low carbon economy for the following sectors: i.e., energy security, industries, transportation, public infrastructure, waste management, human settlements, forestry and agriculture. - Promoting construction of green buildings in commercial/ institutional, industrial and residential sectors. - The policy is based on 5 principles and 10 strategic thrusts. A total of 43 key actions have been identified to achieve the goals of the 10 strategic thrusts in the Policy. - One of the strategic thrusts is to consolidate the energy policy incorporating management practices that enhances renewable energy (RE) and energy efficiency (EE). This strategy should be undertaken by promoting RE and EE for power generation through burden sharing between government and power producers, establishment of EE and RE targets or standards and inclusion of RE in generation mix by power producers and promotion of RE generation by small and independent developers including local communities.			

table continues...

Name	Type of intervention: Policy/ Legislation/ Programme	Scope: Level- National/ State/ Local Body	Start/ End Date (Status)	Method/ Institution(s) Responsible for Implementation	Objectives/ Main Provisions/ Key Emphasis	Progress/ Achievements	Gaps/ Issues	Further Action
National Renewable Energy Policy	Policy	National	2010	MEGTW	- 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 generation - To enhance awareness on the role and importance of RE	- Inclusion of RE generation mix by power producers and its development is supported under the 10th Malaysia Plan (2011-2015) in better handling of resources - The Bakun Hydroelectric projects (2400 MW) in Sarawak will provide enough supply of electricity to the state for many years . 300 MW of power available for Sarawak Energy Berhad (SEB) by August 6 2011. - In addition to the new power plants, TNB has also allocated funds to strengthen and expand the network of transmission and distribution ensuring supply reliability throughout the nation including locations such as Salak South Mahkota Cheras, South Pantai and Puchong Perdana Olak Lampit.	In energy sector, development of RE particularly hydro as well as importation of coal and liquefied natural gas (LNG) by 2015 will improve security of supply]	- Tenaga Nasional Berhad (TNB) developed two new hydro power plants which are Ulu Jelai and Hulu Terengganu with the combined capacity of 622 MW. These two hydroelectric plants are to be commissioned in Peninsular Malaysia cost about RM 4 billion of investment by TNB. Furthermore, the solar thermal power plant located in Putrajaya is expected to be commissioned by 2012. - In Sabah, three new power plants are to be commissioned with a combined capacity of 700 MW. - Two new coal-fired power generation plants with the capability of generating 1000 MW each to be built in the Peninsular Malaysia in which one in Tanjung Bin in Johor and the other in Manjong, Perak. These new plants will be constructed by March 2016.

APPENDIX 3.3

Projection of Population (in '000s)

Year	Malaysia Population	Urban Population	% Share	Rural Population	% Share
2011	28,553	18,131	64%	10,422	36%
2012	28,855	18,350	64%	10,505	36%
2013	29,157	18,565	64%	10,592	36%
2014	29,463	18,781	64%	10,682	36%
2015	29,774	18,997	64%	10,776	36%
2016	30,141	19,250	64%	10,891	36%
2017	30,511	19,502	64%	11,009	36%
2018	30,883	19,753	64%	11,129	36%
2019	31,255	20,004	64%	11,252	36%
2020	31,628	20,253	64%	11,375	36%
2021	31,989	20,667	65%	11,298	35%
2022	32,353	21,090	65%	11,222	35%
2023	32,722	21,521	66%	11,146	34%
2024	33,095	21,961	66%	11,070	33%
2025	33,472	22,410	67%	10,995	33%
2026	33,854	22,868	68%	10,920	32%
2027	34,240	23,336	68%	10,846	32%
2028	34,630	23,813	69%	10,773	31%
2029	35,025	24,300	69%	10,700	31%
2030	35,424	24,797	70%	10,627	30%
2031	35,828	25,151	70%	10,676	30%
2032	36,237	25,510	70%	10,725	30%
2033	36,650	25,874	71%	10,774	29%
2034	37,068	26,243	71%	10,823	29%
2035	37,490	26,618	71%	10,872	29%

Source: EPU,2012

APPENDIX 3.4

Power Sector

Table A3.4.1: Power Fuel Mix- BAU (Capacity-MW)

Type of Fuel	2010	2015	2020	2025	2030
Nuclear	0.0%	0.0%	0.0%	0.0%	0.0%
Hydro	8.6%	9.5%	10.5%	12.4%	12.8%
Gas	57.8%	51.4%	40.2%	39.1%	33.5%
Coal	31.4%	35.2%	45.3%	44.0%	49.3%
Diesel	2.0%	2.0%	1.7%	1.7%	1.5%
Renewable	0.2%	2.0%	2.3%	2.8%	3.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Table A3.4.2 Power Fuel Mix- AMB (Capacity-MW)

Type of Fuel	2010	2015	2020	2025	2030
Nuclear	0.0%	0.0%	0.0%	6.0%	5.2%
Hydro	8.6%	9.3%	13.1%	12.0%	23.5%
Gas	57.8%	50.4%	36.9%	33.8%	27.1%
Coal	31.4%	34.5%	41.6%	38.1%	32.6%
Diesel	2.0%	1.9%	1.6%	1.4%	1.2%
Renewable	0.2%	3.9%	6.8%	8.6%	10.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Table A3.4.3: Power Fuel Mix- BAU (Unit Generated-GWh)

Type of Fuel	2010	2015	2020	2025	2030
Nuclear	0.0%	0.0%	0.0%	0.0%	0.0%
Hydro	5.3%	5.5%	5.9%	5.9%	5.8%
Gas	52.6%	44.8%	43.6%	36.5%	29.1%
Coal	40.8%	46.1%	46.9%	54.0%	61.6%
Diesel	1.3%	1.3%	1.1%	0.9%	0.7%
Renewable	0.0%	2.3%	2.6%	2.7%	2.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Table A3.4.4: Power Fuel Mix- AMB (Unit Generated-GWh)

Type of Fuel	2010	2015	2020	2025	2030
Nuclear	0.0%	0.0%	0.0%	9.3%	7.7%
Hydro	5.3%	5.6%	8.0%	6.8%	12.8%
Gas	52.6%	45.7%	44.9%	37.7%	30.9%
Coal	40.8%	42.6%	37.7%	36.3%	39.1%
Diesel	1.3%	1.3%	1.1%	0.9%	0.7%
Renewable	0.0%	4.8%	8.3%	9.2%	8.8%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Table A3.4.5: Power Fuel Mix- BAU (Capacity-MW)

Type of Fuel	2010	2015	2020	2025	2030
Nuclear	0.0%	0.0%	0.0%	0.0%	0.0%
Hydro	8.6%	9.5%	10.5%	12.4%	12.8%
Fossil Fuel	91.1%	88.6%	87.1%	84.8%	84.2%
Renewable	0.2%	2.0%	2.3%	2.8%	3.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Table A3.4.6: Power Fuel Mix- AMB (Capacity-MW)

Type of Fuel	2010	2015	2020	2025	2030
Nuclear	0.0%	0.0%	0.0%	6.0%	5.2%
Hydro	8.6%	9.3%	13.1%	12.0%	23.5%
Fossil Fuel	91.1%	86.8%	80.0%	73.3%	61.0%
Renewable	0.2%	3.9%	6.8%	8.6%	10.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Note:

1. Table A3.4.5 shows the total fuel mix from fossil fuel for BAU scenario in 2010 was 91.1% decreasing to 87.1% and 84.2% in 2020 and 2030 respectively.
2. Table A3.4.6 shows that in the AMB scenario the total fuel mix has further decrease from 91.1% in 2010 to 80% and 61% in 2020 and 2030 respectively.

APPENDIX 4.1

Technology Transfer and Technology Need Assessment

Technology transfer is one of the major agreements in the climate change negotiations. The article 4.5 of the UNFCCC states that developed countries: “...shall take all practicable steps to promote, facilitate, and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention.”

In addition article 4.7 of the UNFCCC states that “The extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective implementation by developed country Parties of their commitments related to financial resources and transfer of technology ...”

Moreover, the importance of transferring Environmentally Sound Technologies (EST) to developing countries - in the context of enabling the participation of developing countries in climate change mitigation efforts - are stipulated in the Bali Action Plan (2007). The Bali Action Plan stresses “a comprehensive process to enable the full, effective and sustained implementation of the Convention through long-term cooperative action [...] by addressing, inter alia: Enhanced action on technology development and transfer to support action on mitigation and adaptation, including, inter alia, consideration of:

- i. *Effective mechanisms and enhanced means for the removal of obstacles to, and provision of financial and other incentives for, scaling up of the development and transfer of technology to developing country Parties in order to promote access to affordable environmentally sound technologies;*
- ii. *Ways to accelerate deployment, diffusion and transfer of affordable environmentally sound technologies;*
- iii. *Cooperation on research and development of current, new and innovative technology, including win-win solutions;*
- iv. *The effectiveness of mechanisms and tools for technology cooperation in specific sectors.”*

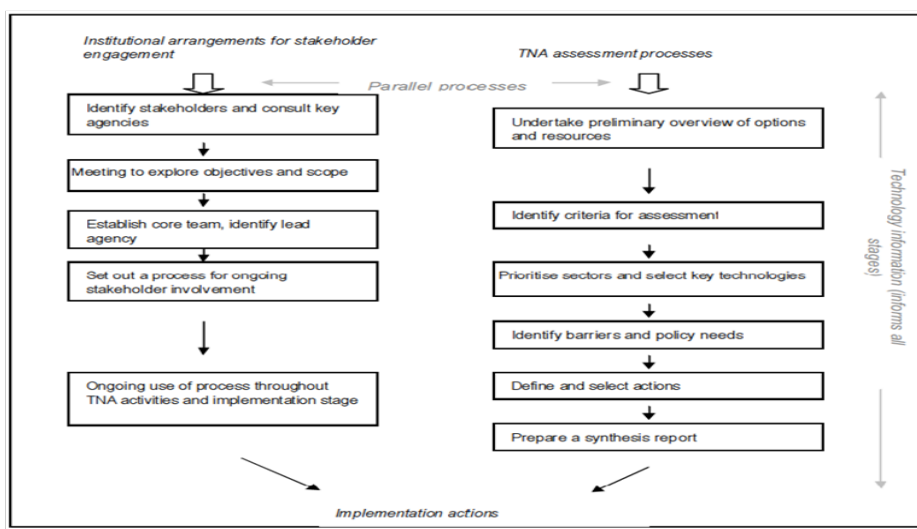
Thus, to obtain support for the technology transfer, developing countries are supposed to carry out Technology Needs Assessment (TNA) and report to the UNFCCC. The TNA is the first step in setting up a technology transfer framework. TNA entails the identification and evaluation of technical means for achieving specified ends (UNDP, 2004). Technology transfer is a broad set of processes covering the flow of know-how, experience and equipment for mitigating and/or adapting to climate change amongst different stakeholders in the country such as: governments, private sector entities, financial institutions, NGOs and research/educational institutions. From a climate change and developmental perspective, TNA prioritizes technologies, practices, and policy reforms that can be implemented in different sectors of a country to reduce greenhouse gas emissions and/or to adapt to the impacts of climate change by enhancing resilience and/or contributing to sustainable development goals.

Methodology

The methodology of TNA is explained in the following section:

Guidelines

The TNA has followed the guidelines from the UNDP/GEF Handbook on methodologies for technology needs assessment and the Climate Technology Initiative (CTI) publication *Methods for Climate Change Technology Transfer Needs Assessments and Implementing Activities: Experiences of Developing and Transition Countries*. In the remainder of this section, these two key documents are further referred to as the GEF 'Handbook' and the CTI 'Methods'. These texts are the result of the combined efforts of worldwide experts in technology transfer, and extensive feedback from different countries where TNAs have been undertaken. Figure 1 gives an overview of the action recommended by the UNDP/GEF 'Handbook'.



Overview of action recommended by UNDP/GEF Handbook

Source: UNDP/GEF (2003)

While the GEF 'Handbook' and CTI 'Methods' specify that no actions can be prescribed since technological conditions and priorities for development differ significantly throughout the world, both documents do provide a number of suggested components:

- Institutional arrangements and stakeholder engagement;
- Descriptions of TNA processes and activities; and
- Implementation actions.

Institutional Arrangement and Stakeholders Engagement

In terms of institutional arrangements and stakeholders engagement, the GEF has recommended course of action to identify representative members of the following categories:

- i. Government departments with responsibility for
 - Relevant areas of policy – energy, environment and development;
 - Regulation of relevant sectors – energy, agriculture, forestry, water, etc.;
 - Promotion and development of industry and international trade;
 - Coastal zone management and drainage;
 - Finance.
- ii. Industries and/or public sector bodies responsible for provision of utility services (energy, water, etc);
- iii. Representative companies or bodies in other greenhouse gas intensive sectors (e.g. energy intensive industry);
- iv. Companies, industry and financial institutions involved in the manufacturing, import and sale of climate response technologies;
- v. Households, small businesses and farmers using the technologies and practices in question, and/or who are experiencing some of the vicissitudes of climate change;
- vi. NGOs involved with the promotion of environmental and social objectives;
- vii. Institutions that provide technical and scientific support to both government and industry (academic organisations, industry R&D, think tanks, consultants);
- viii. Labour unions;
- ix. Consumer groups;
- x. Country divisions of international companies responsible for investments of critical importance to climate policy (e.g. in the energy sector);
- xi. International organisations and donors.

The GEF 'Handbook' distinguishes between the wider group of affected and interested parties who participate in workshops at specific milestones, and a core team, who will drive the TNA; led by a lead organization and assisted by a lead technical institution. The CTI Methods refer to a technology transfer collaborative team or a collection of TT teams and adds that "(...) the composition of such a team depends on an individual country's circumstances. However, one common element of these teams has been the central role of government in coordinating and focusing the team's activities toward achievement of national development and economic goals".

TNA Processes and Activities

In terms of TNA processes and activities, the UNDP/GEF 'Handbook' distinguishes the following steps:

- Prepare a preliminary overview of options and resources;
- Identify criteria for technology assessment; and
- Identify priority sectors and select technologies.

The preliminary overview of technology options and resources is a data gathering exercise that must be undertaken before detailed technology evaluation can be undertaken. The GEF 'Handbook' recommends that this stage should not become a long and complex task as it need not provide a detailed picture of all technology options in all sectors. Rather, it should provide a broad overview to allow the best technology options to be pursued in the sectors with the greatest scope for initial actions. The scope of the TNA needs to be identified in this phase. Suggested sectors in the GEF 'Handbook' are:

- i. Electricity production, transmission and use;
- ii. Other energy supply sectors – natural gas, LPG and other domestic fuels;
- iii. Transport – fuels, vehicles, public and private transport infrastructure;
- iv. Forestry;
- v. Agriculture;
- vi. Energy intensive industries;
- vii. Climate technology industries or industries with potential manufacture/supply climate response technologies;
- viii. Waste management and recycling;
- ix. Buildings and construction;
- x. Water management;
- xi. Coastal zone management and defences; and
- xii. Health.

To prioritise the highlighted sectors above, it is suggested to undertake the following steps:

- Brief review of current circumstances of key sectors – technologies in use, GHG emission and financial conditions;
- Brief review of potential to reduce emissions and contribute to adaptive response by sector;
- Brief review of country wide low carbon energy resources and main technology options, and adaptive responses and main technology options.

To identify criteria for technology assessment is to determine a criterion whereby actions may be judged against their contribution to national development goals. It also requires that the cost effectiveness of so doing, in terms of the (possible) higher costs of new and alternative technologies, is considered. This requires some means by which the different goals can be prioritized, such that trade-offs between objectives, should they occur, can be dealt with fairly and transparently.

The 'Handbook' puts forward the following factors on which the criteria for selecting sectors and technologies for TNA will depend:

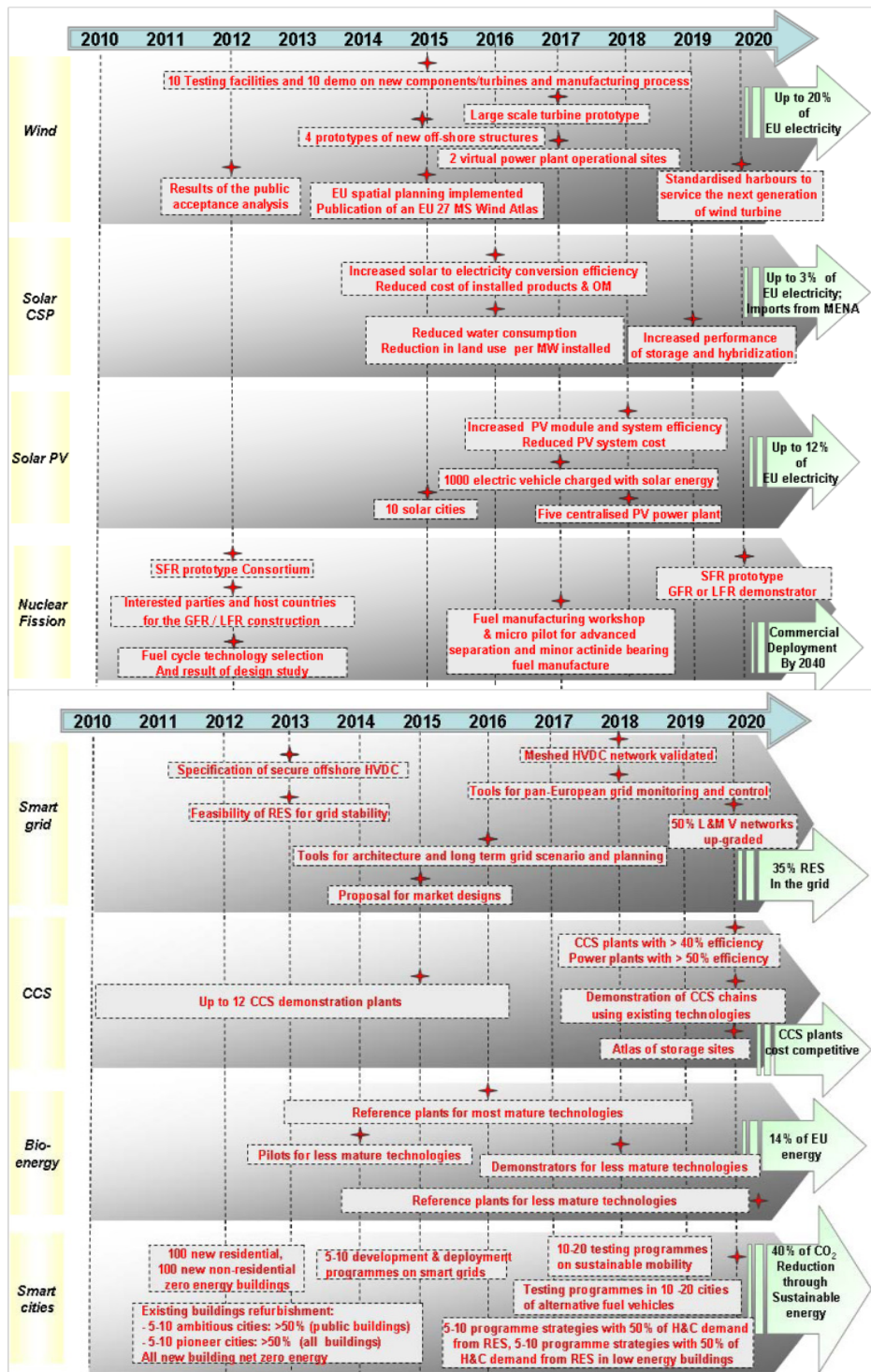
- Contribution to the wider policy goals of development;
- The contribution to climate change mitigation or adaptation; and
- The market potential.

For the purpose of this report, it is noted that NOT ALL of the procedures that have been suggested by GEF and CIT are considered. Given the limitations, the selections of sectors are based on the Second National Communication published by the Ministry of Natural Resources and Environment in 2011.

APPENDIX 4.2

European Country LCE

No	European Industrial Initiatives	Technology
1	20% of the EU electricity will be produced by wind energy technologies by 2020	Wind energy
2	15% of the EU electricity will be generated by solar energy in 2020	Solar energy –PV & CSP
3	The electricity grid in Europe will be able to integrate up to 35% renewable electricity in a seamless way and operate along the "smart" principle, effectively matching supply and demand by 2020	Electricity grid
4	At least 14% of the EU energy mix will be from cost-competitive, sustainable bio-energy by 2020	Bio energy
5	Carbon capture and storage technologies will become cost-competitive within a carbon pricing environment by 2020-2025	Carbon Capture and Storage (CCS)
6	Existing nuclear technologies will continue to provide around 30% of EU electricity in the next decades, the first Generation-IV nuclear reactor prototypes will be in operation by 2020	Sustainable Nuclear Energy
7	25 to 30 European cities will be at the forefront of the transition to a low carbon economy by 2020.	Smart Cities



APPENDIX 4.3

LCE options by Japan

Actions contribute to CO₂ reduction

No	European Industrial Initiatives	Technology
Commercial and residential	• Comfortable and green built environment • Anytime, Anywhere • Appropriate appliances	• Efficiently use of sunlight and energy efficient built environment design • Intelligent buildings • Use of top-runner and appropriate appliances • Initial cost reduction by rent and release system resulting in improved availability
Industrial	• Promoting seasonal local food • Consuming in-season local • Environmentally enlightened business and industry	• Supply of seasonal and safe low carbon local foods for local cuisine • Using local and renewable buildings materials and products • Business aiming at creating and operating in LC market • Supplying LC and high value-added goods and services through energy efficient products systems
Transportation	• Swift and smooth logistics • Pedestrian friendly city design	• Networking seamless logistics system with supply chain management using both transportation and ICT infrastructure • City design requiring short trips and pedestrian (and bicycle) friendly transport, augmented by efficient public transport.
Energy transmission	• Low carbon electricity • Local renewables for local demand • Next generation fuels	• Supplying low carbon electricity by large scale renewables, nuclear power and CCS equipped fossil (and biomass) fired plants • Enhancing local renewables use, such as solar, wind, biomass and others • Development of carbon free hydrogen and/or biomass based energy supply system with required infrastructure
All sectors	• Labelling to encourage smart and rational choices • Low carbon society leadership	• Publishing of energy use and CO₂ costs information for smart choices of LC goods and service by consumers, and public acknowledgement of such consumers • Human resource development for building 'Low Carbon Society' and recognizing extraordinary contributors

Two narrative scenarios for Japan low-carbon society at 2050

Scenario A	Scenario B
• Vivid, Technology-driven • Urban/Personal • Technology breakthrough • Centralized production/recycling • Comfortable and Convenient • 2%/yr GDP per capita growth • Dependent on import products in agriculture sector • Shifting production sites to overseas • Market deregulation	• Slow, Natural-oriented • Decentralized/Community • Self-sufficient • Produced locally, consumed locally • Social and Cultural Values • 1%/yr GDP per capita growth • Revival of public interest in agriculture • High-mix low-volume production with local brand • Adequate regulated rules apply in market

Adapted from: National Institute for Environmental Studies (NIES), and Mizuho Information and Research Institute . (2009). Japan Roadmaps towards Low-Carbon Societies (LCSs):2050 Japan Low-Carbon Society . Japan : National Institute for Environmental Studies (NIES), and Mizuho Information and Research Institute

APPENDIX 4.4

LCE options by Kyoto

Action for Low Carbon cities

Action	Description
Walkable city	- Targeted to reduce CO₂ emission in 2030 by 722 kt-CO₂. - Road pricing - Introduction of light rail transit (LRT) - Promotion of mobility management - Promote the use of public transport by the general public. - Implementation of transport demand management (TDM) - Construction of pedestrian transit malls - A shift from the use of privately owned automobiles to the use of public transport by the general public - The use of pedestrian transit malls by the general public will enable CO₂ emissions to be reduced by 32 kt-CO₂
Kyoto-style building and forest management	- Improvement of consultation system for energy-efficient buildings - To promote the conversion of buildings to highly insulated residences when renovating existing homes - Energy efficient residence advisor program - To train and dispatch advisors program who are experts on energy-efficient buildings for homes - Comprehensive assessment system for building environmental efficiency (CASBEE) - Recognition of buildings that make an outstanding effort to preserve scenic beauty and create a low carbon society - CASBEE program will promote the construction of residential areas and offices with improved insulation - Reducing CO₂ emissions by 50 kt-CO₂ (residences) and 231 kt-CO₂ (offices)
Low carbon lifestyle	- Breaking away from the large consumption lifestyle - Shifting to equipment with outstanding energy efficiency - Encouraging the general public to conserve energy - Environmental education in schools - Children's eco-life challenge project
Decarbonation of industry	- Targeted to reduce CO₂ emission in 2030 by 1453 kt-CO₂ - Large emitter programs - Companies in private sector that use large quantities of are required to submit a 3 year green house gas reduction plan and report to emission annually. - This activity will be able to reduce CO₂ emissions by 421 kt-CO₂ - Promotion of KES certification - Promote the introduction of highly energy-efficiency facilities and equipment and encourage energy saving behaviour at small and medium sized companies

table continues...

Action	Description
Comprehensive use of renewable energy	• Able to reduce CO₂ emissions in 2030 by 513 kt-CO₂ • Promotion of PV equipment installation in private sector facilities • Provide assistant for installing solar energy equipment in homes in order to promote dissemination in the general public • Installation of PV/SWH in public facilities • Will be promoted by the city as an initiative for new public facilities. The dissemination of PV/SWH equipment will be able to reduce CO₂ emissions by 72 kt-CO₂ • Promotion of biomass use • Development of technology through industry-academia government cooperation.
Establishment of a funding mechanism	• Development of Kyoto carbon offset model project • Companies in the private sector will identify the emissions that are difficult to reduce in their activities for the year and they will be able to offset these by purchasing environmental credits to obtain from the use of solar energy generation and other energy efficient activities.

Adapted from: Kyoto, Research Team of Sustainable Society. (2009). A Roadmap Towards Low Carbon Kyoto. Kyoto.

APPENDIX 4.5

LCE options by Korea

Three strategies and 10 policy directions in Korea's 5 year green growth plan

Strategies	Policy Directions
Measures for climate change and securing energy independence	• Reduce carbon emissions • Decrease energy dependence and enhance energy self-sufficient • Support adaptation to climate change impacts
Creation of new growth engines	• Develop green technologies as future growth engines • Enhance green industry • Develop cutting-edge industries • Set up policy infrastructure for green growth
Improving quality of life and strengthening the status of the country	• Green city and green transport • Green revolution in lifestyle • Enhance global cooperation on green growth

- Cost on the green growth plan expected to stimulate production worth 182 to 206 trillion won (US\$ 141.1 billion to US\$ 160.4 billion) during 2009-2013 with yearly average production inducement of 36.3 to 41.2 trillion won.
- Implementation of 5-year plan expects to create jobs in green industries for 1.18 to 1.47 million people during the 5 years plan

Key aspects of the National Strategy and 5-year plan for Green Growth

Key Aspect	National Strategy
Climate change	• Korea's carbon emission would be reduced by 21%, 27% and 30% from three options Scenario 1 • 21% reduction from BAU (8% increase from 2005 level. Achieved through implementation of measures with short-term cost but potential long-term benefits Scenario 2 • 27% reduction from BAU (return to 2005 level). Implementation of additional measures from scenario 1 which have mitigation cost of less than 50000 won (approx. US\$ 28) per ton of CO₂ Scenario 3 • 30% reduction from BAU (4% reduction from 2005 level). Implementation of aggressive measures with high mitigation cost. Adoption of new auto emission standards, a waste-to-energy programme to reduce GHG emissions from waste materials, promoting low-carbon transportation, the introduction of light-emitting diodes (LEDs), stricter heat insulation standards for buildings, and development of carbon capture storage (CCS) technologies. • Forest sector is expected to reduce emissions from 1.452 billion CO₂ ton to 1.613 billion CO₂ ton in 2013. Increase capacity of national forest resources from 862 million cubic meters to 953 million cubic meters by enhancing forest protection and forest ecosystem management programmes

table continues...

Key Aspect	National Strategy
Energy efficiency	• Transport sector • New standards to increase the fuel efficiency for automobiles and institute reporting system • Introducing a ban incandescent lights which have low energy performance • Changing electricity pricing system into a cost-based electricity pricing system. • Development and dissemination of hybrid electric-vehicles, the adaptation of stringent standards on fuel efficiency, energy conservation and green buildings and the promotion of investment in energy conservation facilities.
Renewable and nuclear energy	• Increase share of new and renewable energy in total energy supply from 2.7% in 2009 to 3.78% in 2013, and 6.08% in 2020. • Renewable energy will be generated from 1 Million Green Homes Project and thus reduce country's carbon footprint • Expand assistance for national strategic technology development in areas of solar and bio-energy technologies
Transport, cities and fuel efficiency	• Setting fuel economy standards • Ensuring that non-motorized transport modes are encourage through the integration of cycling lanes within the larger transport infrastructure, especially public transport both in urban and rural areas • GHG reduction is targeted at 31% by 2020 for building sector. The target includes strengthening energy standards by 30% by 2012, achieving passive level by 2017 and zero-energy housing by 2025
Water and ecological infrastructure	• 4 major rivers restoration – to secure abundant water resources, create systems for flood control, improve water quality, restore ecosystems, and create opportunities for rural development.
Green technologies	• Promote development of 27 core green technologies that would provide future engines growth

Adapted from: Park, H. J. (2009). Korea goes for 'Low Carbon, Green Growth'.

APPENDIX 4.6

LCE options by Vietnam

Five Actions towards LCS (Potential mitigation in 2030)

Action	Description
a. Convenient Transport	The action on convenient transport primarily comprises of a shift from private vehicles to public transportation by traffic management system and increased penetration of fuel switch. Total CO₂ emission reduction from this action contributes to 16% of total CO₂ emission reduction. Currently, Vietnam has paid due attention to transport demand management which includes transport infrastructure development (focusing investment on road network development, building new and upgrading key national highways), investment to public vehicles, and bold policy to control and reduce the use of motorbikes.
b. Green Building	The “Green Building” action focuses on measures of fuel shifting and natural energy utilization of two sectors (residential and commercial). This action is targeted to reduce CO₂ emissions in 2030 by 12.6 million t-CO₂ and 15.3 million t-CO₂ in the two sectors: commercial and residential. Fuel shifting and natural energy utilization comprise the following measures such as: biomass heating, solar heating, photovoltaic power and solar water heater. This action contributes to 39% and 48% CO₂ emission reduction as compared to total CO₂ emission reduction in commercial and residential sector. Policies concerning: 1. subsidy to introduce natural energy system (solar and wind energy, photovoltaic power), 2. low interest loan in investment to building using renewable energy, 3. environmental performance standard and evaluation of housing and buildings.

table continues...

Action	Description
c. Energy Efficiency Improvement	The "Energy Efficiency Improvement" action is able to reduce CO₂ emissions in all sectors by 77.7 million t-CO₂ in 2030, accounting for about 38% as compared to the total CO₂ emission reduction. This action is used to turn the existing or low-efficiency device, equipment, motors or vehicles into "best available technology" models in all sectors. "Nation Strategic Program on Energy Saving and Effective Use" is used in order to implement this action.
d. Fuel switch of Industry	The action "Fuel Switch in Industry" is targeted to reduce CO₂ emission by 28.0 million t-CO₂ or 14% of total CO₂ emission in 2030. In which, largest potential reduction is accounted for steam boiler by 17.8 million t-CO₂, following by direct heating (furnace) by 8,549 kt-CO₂, and other activities by 1,734 kt-CO₂. Fuel uses in industrial sector, will be able to shift from high carbon intensity to lower carbon intensive. For instance, fuel is switched from coal and oil to natural gas. To promote mitigation measures of industrial sector, incentive to investment in fuel switch is essentially important. Policies for this sector focus on tax, subsidy and low interest loans.
e. Smart Power Plants	The action "Smart Power Plants" is calculated to reduce CO₂ emission by 26.8 million t-CO₂ or 18% of total CO₂ emission in 2030. There are 4 main measures: 1. Utilizing economically efficient domestic energy resources, 2. Promoting the use of renewable energies, 3. Reducing transmission and distribution loss, 4. Developing nuclear power plant The transmission loss in 2005 was 11.3% and this number will reduce to 9% in 2030 BAU case and 7.5% in 2030 Counter Mitigation Measures (CM).

Asia Pacific Integrated Model Team, GCOE on Human Security Engineering for Asian Megacities-Kyoto University. Preliminary Study on Sustainable Low-Carbon Development Towards 2030 in Vietnam . National Institute for Environmental Studies.

Liu Qiang, J. K. Low Carbon Scenario up to 2050 for China. Eight Asia-Pacific Conference on Climate Change. Hanoi, Vietnam: Energy Research Institute.

APPENDIX 4.7

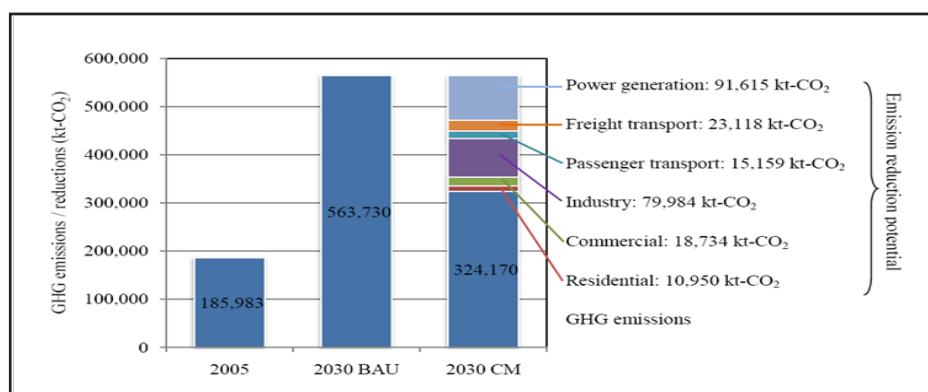
LCE options for Thailand

GHG mitigation potential

Sector	Mitigation Potential
Residential	Energy demand is determined based on GDP, number of household and population. GHG mitigation is efficient by improving electric devices and efficiency improvement in the electricity generation sector
Commercial	Estimated based on the floor space of the buildings. The mitigation measures identified in this sector are efficiency improvements in electric devices (1,6384kt-CO ₂ , 30.5%), building insulation (2,350 kt-CO ₂ , 4.4%), and the power sector (34,896 kt- CO ₂ , 65.1%)
Industry	Energy efficiency improvement and fuel shifting could reduce GHG emissions by 122,492 kt- CO ₂ (44%) of CO ₂ reduction in industry
Transport (passenger)	Energy efficiency improvement, travel demand management, modal shift and fuel substitution could mitigate GHG emissions at 15,452 kt-CO ₂ (59.7%) of CO ₂ reduction
Transport (freight)	Energy efficiency improvement, travel demand management, modal shift and fuel substitution could mitigate GHG emissions at 23,127 kt-CO ₂ of CO ₂ reduction

CO₂ eq. mitigation potential in 2030

Power generation	38.2%
Industrial sector	33.4%
Freight transport sector	9.6%
Commercial sector	7.8%
Passenger transport sector	6.3%
Residential sector	4.6%



Breakdown of CO₂ emission reduction potential

Adapted from: Asian Institute of Technology, National Institute of Environmental Studies, Kyoto University. Thailand's Low-Carbon Society Vision 2030. Asia-Pacific Integrated Model.

APPENDIX 4.8

LCE option for Shenzhen, China

GHG mitigation potential

Sector	Mitigation Potential
Steel Industry	Large size equipment (coke oven, blast furnace, basic oxygen furnace etc.), equipment of coke dry quenching, continuous casting machine, TRT continuous rolling machine, equipment of coke oven gas, OH gas and BOF gas recovery , DC-electric arc furnace
Chemical Industry	Large size equipment for chemical production, waste heat recover system, ion membrane technology, existing technology improving
Paper Making	Co-generation system, facilities of residue heat utilization, black liquor recovery system, continuous distillation system
Textile	Co-generation system, shuttleless loom, high speed printing and dyeing
Non-ferrous metal	Reverberator furnace, waste heat recover system, QSL process for lead and zinc production
Building	Materials dry process rotary kiln with pre-calciner, electric power generator with residue heat, colburn process, hoffman kiln, tunnel kiln
Machinery	High speed cutting, electric-hydraulic hammer, heat preservation furnace
Residential	Cooking by gas, centralized space heating system, energy saving electric appliance, high efficient lighting
Service	Centralized space heating system, centralized cooling heating system, co-generation system, energy saving electric appliance, high efficient lighting
Transport	Diesel truck, low energy use car, electric car, natural gas car, electric railway locomotives
Common Use	Technology high efficiency boiler, high efficiency electric motor, speed adjustable motor, centrifugal electric fan, energy saving lighting

table continues...

Sector	Mitigation Potential
Reducing carbon content of energy	- Developing nuclear energy – Lingao Nuclear Station - Developing renewable energy –small to medium size wind power, BIPV, sun-heat, small size PV - Deploying carbon capture and storage (CCS) - Increasing natural gas use and natural gas import - To reduce 20-30% carbon content of energy consumed by 2020
Facilitating low carbon industries and services development to promote economic-growth	- Developing new energy industries - Manufacturing high energy efficiency products –LED,PV-LED, smart grid products and smart meters - Promoting energy efficiency improving services - Facilitating carbon services-monitoring CO₂ emissions , carbon auditing, carbon labelling, carbon trading, carbon finance, carbon insurance - To add RMB30-80 billion, added-values to each special economic zone's (SEZ) gross domestic production by 2020
Slowing energy consumption growth	- Displacing low EE equipment with high EE - Low carbon transportation-public traffic promotion, vehicles' EE improving - Running new energy vehicle – hybrid electric vehicles - Low carbon houses - energy saving behaviours, high EE electric appliances, rolling out of smart meters, green travel, low carbon dietary - To reduce energy intensity by 30-40% by 2020

Sectoral milestones: All sectors contributing in different manner

GHG reductions as compared to 1990	2005	2030	2050
Power (CO ₂ eq.)	-7%	-54 to -68%	-93 to -99%
Industry (CO ₂ eq.)	-20%	-34 to -40%	-83 to -87%
Transport (incl. CO ₂ aviation, excl. maritime)	+30%	+20 to -9%	-54 to -67%
Residential and services (CO ₂ eq.)	-12%	-37 to -53%	-88 to -91%
Agriculture (non- CO ₂ eq.)	-20%	-36 to -37%	-42 to -49%
Other non-CO ₂ emissions	-30%	-72 to -73%	-70 to -78%

Adapted from: Wang T., Z. Z. (2005). Towards Low-Carbon Cities of China's SEZs: The Case of Shenzhen

APPENDIX 4.9

LCE options for Jilin City China

Low carbon development

This project proposes a new methodology based on four key areas. Benchmarks in each area can be adjusted to reflect different local development conditions.

- Low carbon productivity includes indicators for both carbon and energy per unit of economic output, measurements consistent with China's existing energy-intensity and carbon-intensity targets.
- Low carbon consumption covers per capita and per household energy consumption. Consumption indicators can be used to review the impacts of policy on individual behaviour.
- Low carbon resources cover the share of low carbon energy, emissions per unit of energy production and the percentage of land covered by forest.
- Low carbon policy indicators review the existence of policies and plans for low carbon development, success in implementation of regulations, and public awareness levels.

The roadmap proposes an improvement of Jilin City's carbon intensity by 58% in 2020 as compared to 2005. This means that in 2020, greenhouse gas emissions would be 19% lower than in the BAU scenario and that of 2015 (the final year of the 12th Five-Year Plan).

Proprieties for investment in the 12th Five Year Plan

Technology upgrade: Currently less than 10% of the production equipment used in Jilin City is said to be of 'international or domestic advanced level'. As a consequence, there is a definitive plan to accelerate the scrapping of redundant and outdated equipment. International cooperation and investment could play an important role.

Renewable and low carbon energy: Jilin City is set to comprehensively develop renewable energy, combining its wealth of resources with its strength in manufacturing. Its position at the heart of the northeast grid gives it a major advantage in connecting renewable generation to the network. Jilin City will need to invest RMB 56 billion in power generation by 2020 to meet the demand – and more if Jilin City chooses a higher share of low carbon energy. Three low carbon energy projects have been identified to which if implemented together would reduce Jilin City's CO₂ emissions by over 20% compared to BAU in 2020.

Building efficiency: Meeting the 65% buildings efficiency target in Jilin City would require an additional investment of RMB 2.6 billion per annum. The lower energy prices charged to consumers in Jilin City mean that it would take about 30 years for the investment costs to be recovered, but energy pricing reform could dramatically alter this situation. Jilin City urgently needs energy-saving technology for wall materials and exterior wall thermal insulation. This could be one focus of the proposed technology cooperation platform for Jilin City.

Transport: Jilin City's transport strategy should be a combination of avoiding lock-in through urban design and public transport systems; encouraging the manufacture and sale of lower carbon vehicles; and shifting the vehicle-manufacturing base to creating a platform for exports.

Agriculture and Forestry: Opportunities for low carbon development also abound in rural areas. Jilin City could focus on increasing the use of renewable energy sources in rural areas, such as methane, straw gasification and solar energy. Further greenhouse gas emissions savings could be achieved through changes in agricultural and livestock production methods. In addition, projects to reduce deforestation and forest degradation could be used to mitigate climate change and help to attract international funds.

Low carbon development scenario

BAU scenario: This is based on the current economic development pattern. It includes current policy commitments on energy intensity and other key areas but assumes that no further policies are introduced.

Policy scenario: This shows the effect of additional energy-saving measures, renewable energy promotion and pollution reduction (driven by policy, investment and energy expenditure). The main drivers here are:

- Adjustment of economic structure – high energy-consuming industries contribute a gradually shrinking share of industrial added value.
- The deployment of energy-saving technology.
- Excellence in heavy industry: by 2020, the main high energy-consuming industries will catch up with or exceed advanced-country levels and the industry will generally realize effective and cleaner production.
- Buildings: new buildings reach the energy-saving standard. Consumers purchase efficient electricity using products and make adjustments to their lifestyle. Some install domestic renewable energy.
- Renewable energy will be more rapidly advanced – including wind power, solar thermal utilization, photovoltaic cells, biomass energy power-generation and liquefaction, small-scale hydropower and energy from waste.

Low carbon scenario: All the above policy scenario measures are included. Further efforts are made to decarbonize the energy system – for example by the faster penetration of renewables and nuclear power. In particular, the low carbon scenario includes some optimistic assumptions about the rate of introduction of carbon capture and storage (CCS).

Technologies

Sector	Technologies
Steel industry	Large-size equipment (coke oven, blast furnace, basic oxygen furnace etc), equipment for coke dry quenching, continuous casting machine, top pressure recovery turbine, continuous rolling machine, equipment of coke oven gas, open hearth gas and blast furnace gas recovery, direct-current electric arc furnace
Chemical industry	Large size equipment for chemical production, waste heat recover system, ion membranes technology, existing technology is improving
Paper making	Co-generation system, facilities of residue heat utilization, black liquor recovery, continuous distillation system
Textile	Co-generation system, shuttle less loom, high-speed printing and dyeing
Non-ferrous metal	Reverberator furnace, waste-heat recovery system, Queneau-Schuhmann-Lurgi (QSL) continuous smelting process for lead and zinc production
Building materials	Dry process rotary kiln with pre-calciner, electric power generator with residue heat, Colburn process, Hoffman kiln, tunnel kiln
Machinery	High-speed cutting, electric-hydraulic hammer, heat preservation furnace
Residential	Cooking by gas, centralized space heating system, energy-saving electric appliances, high-efficiency lighting, solar thermal for hot water, insulation of building and energy-efficient windows
Service	Centralized space heating system, centralized cooling heating system, co-generation system, energy saving electric appliances, high-efficiency lighting
Transport	Hybrid vehicle, advanced diesel truck, low energy-use car, electric car, fuel cell vehicle, natural gas car, electric railway locomotive, public transport development
Common-use Technology	High-efficiency boiler, fluidized bed combustion technology, high-efficiency electric motor, speed adjustable motor, centrifugal electric fan, energy-saving lighting
Power generation	Super-critical unit, natural gas combined cycle, pressurized fluidized bed combustion boiler, wind turbine, integrated gasification combined cycle, smaller-scale hydropower, biomass-based power

Source: Energy Research Institute, 2009

Adapted from: Chatham House, Chinese Academy of Social Sciences. (2010). Low Carbon Development Roadmap for Jilin City. Energy Research Institute, Jilin University.

APPENDIX 4.10

Environmental & energy policies in Malaysia

Policy	Details
Petroleum Development Act 1974	Established Petronas as the national oil company and vested it with the responsibility for exploration, development, refining, processing, manufacturing, marketing and distribution of petroleum products
National Energy Policy 1979	Set the overall energy policy with broad guidelines on long-term energy objectives and strategies to ensure efficient, secure and environmentally sustainable supplies of energy
National Depletion Policy 1980	Introduced to safeguard the exploitation of natural oil reserves because of the rapid increase in the production of crude oil
Four Fuel Diversification Policy 1981	Designed to prevent over-dependence on oil as the main energy resource, its aim was to ensure reliability and security of the energy supply by focusing on 4 primary energy resources: oil, gas, hydropower and coal
Fifth Fuel Policy (Eighth Malaysia Plan 2001-2005)	In the 8th Malaysian Plan, renewable energy was announced as the fifth fuel in the energy supply mix. Renewable energy is being targeted to be a significant contributor to the country's total electricity supply. With this objective, greater effort is being undertaken to encourage the utilization of renewable resources such as biomass, biogas, solar and mini hydro for energy generation
Energy Efficiency and Renewable Energy (Ninth Malaysia Plan 2006-2010)	The 9th Plan strengthened the initiative for energy efficiency and renewable energy put forth in the 8th Malaysia Plan that focused on better utilization of energy resources. An emphasis to further reduce the dependency on petroleum provided for more efforts to integrate alternative fuels.

Cross Cutting	Objectives
Residential and Commercial Sector	
Electricity Supply Act 1990 (Amended) 2001 or Act A1116	- Provisions on the efficient use of electricity - Section 23A: The Minister may, from time to time, prescribe the standards, specifications, practices and measures to be adopted and any other matters in regard to the efficient use of electricity. - Section 23B: No person shall use or operate any installation unless the installation meets such requirements as may be prescribed in regard to the efficient use of electricity. - Section 23C: No person shall manufacture, import, sell or offer for sale or lease any equipment unless the equipment meets such requirements as may be prescribed in regard to the efficient use of electricity
Energy Commission Act (2001) (Amendment 2009)	- The Energy Commission (or Suruhanjaya Tenaga) was established - To provide technical and performance regulation for the electricity and piped gas supply industries - To advise the government on matters relating to electricity and piped gas supply including energy efficiency and renewable energy issues
The Efficient Management of Electrical Energy Regulations 2008 - under the Electricity Supply Act 1990	- To promote efficient use of electrical energy through a better energy planning and management system for industry and commercial - Any installation with total electricity consumption of 3 million kWh or more over six consecutive months to appoint electrical energy managers and implement efficient electrical energy management.
Environmental Quality Act 1974	To provide legal basis for coordinating all activities relating to the protection of environment
National Energy Policy	- Formulated with broad guidelines on long-term energy objectives and strategies to ensure efficient, secure and environmentally sustainable supplies of energy. - It has Three main objectives: - Supply objective: To ensure the provision of adequate, secure, and cost-effective energy supplies through developing indigenous energy resources both non-renewable and renewable energy resources using the least cost options and diversification of supply sources both from within and outside the country - Utilization objective: To promote the efficient utilization of energy and to discourage wasteful and non-productive patterns of energy consumption - Environment objective: To minimize the negative impacts of energy production, transportation, conversion, utilization and consumption on the environment
National Green Technology Policy	- To reduce the energy usage rate and at the same time increase economic growth - To facilitate the growth of the green technology industry and enhance its contribution to the national economy

table continues...

Cross Cutting	Objectives
	- To increase national capability and capacity for innovation in green technology development and enhance Malaysia's competitiveness in green technology in the global arena. - To ensure sustainable development and conserve the environment for future generations - To enhance public education and awareness on green technology and encourage its widespread use
National Policy on Climate Change (2009)	- Mainstreaming climate change through wise management of resources and enhanced environmental conservation resulting in strengthened economic competitiveness and improved quality of life - Integration of responses into national policies, plans and programmes to strengthen the resilience of development from arising and potential impacts of climate change - Strengthening of institutional and implementation capacity to better harness opportunities to reduce negative impacts of climate change - Consolidating the energy policy incorporating management practices that enhances Renewable Energy (RE) and Energy Efficiency (EE) - Empowering local communities in basic RE maintenance, especially in rural electrification including mini and micro hydroelectric schemes - Identifying and recommending options towards low carbon economy for the following sectors; i.e., energy security, industries, transportation, public infrastructure, waste management, human settlements, forestry and agriculture. - Promoting construction of green buildings in commercial/ institutional, industrial and residential sectors
Five-Fuel Policy (2001)	Introduced in recognition of the potential of biomass, biogas, municipal waste, solar and mini hydro as potential renewable energy resources for electricity generation
National Renewable Energy Policy (2010)	- 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 generation - To enhance awareness on the role and importance of RE
National Mineral Policy	Providing the foundation for the development of an effective, efficient and competitive regulatory environment for the mineral sector
National Vision Policy	- Aimed to establish a united, progressive and prosperous Bangsa Malaysia. It endeavours to build a resilient and competitive nation, and equitable society with the overriding objective of National Unity. - It has seven critical thrusts, as follows: - Building a resilient nation; - Promoting an equitable society; - Sustaining high economic growth; - Enhancing competitiveness; - Developing a knowledge-based economy; - Strengthening human resource development; and - Pursuing environmentally sustainable development

table continues...

Cross Cutting	Objectives
National Petroleum Policy (1975)	Introduced to ensure optimal use of petroleum resources and regulation of ownership, management and operation, and economic, social, and environmental safeguards in the exploration of petroleum due to a fast growing petroleum industry in Malaysia
The National Policy on the Environment 2002	- The objectives of the policy: - A clean, safe healthy and productive environment for present and future generations - Conservation of the country's unique and diverse cultural and natural heritage with effective participation from all sectors of the society - Sustainable lifestyles and patterns of consumption and production
Science & Technology Policy, 1986 (MOSTI)	- The scheme aims to promote green technology by availing loans/financing to companies that supply an utilize green technology . - The objective of the scheme is to promote investments in Green Technology which refers to products, equipment, or systems which satisfy the following criteria: (a) minimizes the degradation of the environment (b) has a zero or low green house gas (GHG) emission (c) safe for use and promotes healthy and improved environment for all forms of life (d) conserves the use of energy and natural resources (c) promotes the use of renewable resources
Green Technology Financing Scheme (GTFS)	- The scheme aims to promote green technology by availing loans/financing to companies that supply an utilize green technology . - The objective of the scheme is to promote investments in Green Technology which refers to products, equipment, or systems which satisfy the following criteria: - minimizes the degradation of the environment - has a zero or low green house gas (GHG) emission - safe for use and promotes healthy and improved environment for all forms of life - conserves the use of energy and natural resources - promotes the use of renewable resources.
MS 1220:2001 - Specification for performance and construction of electric circulating fans and regulators (First Revision)	This standard applies to the types of electric motor directly driven fans and their associated regulators intended for use on single-phase a.c. and d.c. circuits not exceeding 250V. This standard supersedes MS 1220: 1992
MS ISO 8561:2000 - Household frost-free refrigerating appliances— Refrigerators, refrigerator-freezers, frozen food storage cabinets and food freezers cooled by internal forced air circulation – Characteristic and test methods	To specify the essential characteristics for household frozen food storage cabinets and food freezers cooled by internal forced air circulation and for household refrigerators with or without cellar, ice-making or frozen food storage compartments, and of refrigerator-freezers with or without cellar compartment and with at least the food freezer and or frozen food storage compartment(s) cooled by internal forced air circulation, which are wholly factory assemble, and lays down the methods of test for the checking of these characteristics

table continues...

Cross Cutting	Objectives
MS ISO 5151:2004 - Non-ducted air conditioners and heat pumps – Testing and rating for performance	This Malaysian Standard specifies the standard conditions on which the ratings of single-package and split-system non-ducted air conditioners employing air and water cooled condensers are based, and the test methods to be applied for determination of the various rating
MS 1752:2004 - Method for measuring performance of electric toasters for household and similar purposes	This Malaysian Standard applies to electric toasters for household and similar use
MS 1751:2004 - Methods of measuring the performance of electric ironing machines for household and similar purposes	The Standard applies to electric ironing machines for household and similar purposes
MS 1753:2004 - Methods of measurement of performance of electric irons for household or similar use	This Malaysian Standard applies to electric irons for household or similar use. The purpose of this standard is to state and define the principal performance characteristics of electric irons for household or similar use which are of interest to the users and to describe the standard methods for measuring these characteristics
MS 1855:2005 - Clothes washing machines for household use – Methods for measuring the performance	This Malaysian Standard deals with the methods for measuring the performance of clothes washing for household use with or without heating devices and for cold and/or hot water supply
Agriculture Sector	
Third Outline Perspective Plan (OPP3).- Agricultural Policy Framework	- To restructure and modernize the agriculture sector to be a dynamic and competitive sector: 1. Expanding food production to reduce import and increasing export 2. Promoting private sector participation in medium and large-scale commercial food production through permanent food production zone 3. Intensifying aquaculture development, both inland and open sea 4. Intensifying land-use, promoting cost-and labour-saving technology 5. Intensifying R&D and commercialization of R&D findings 6. Consolidating oil palm hectrage 7. Utilising natural resources, particularly forestry on sustainable basis and promoting linkages with other sectors 8. Developing activities and crops with commercial potential including speciality natural products, including other non-timber forest products, biotechnology products, floriculture and ornamental fish 9. Strengthening human resource development by promoting new skills such as those related to ICT and new technologies. 10. Enhancing income of farmers and smallholders through improvement in support services and facilities.

table continues...

Cross Cutting	Objectives
Environmental Quality Act 1974	To prevent, abate, and control of pollution and enhancement of the environment
National Kenaf And Tobacco Board Act 2009 (Act 692)	- A body corporate by the name of "National Kenaf and Tobacco Board" is established - The Board shall have perpetual succession and a common seal, and may sue and be sued in its name. - Subject to and for the purpose of this Act, the Board may, upon such terms as the Board deems fit— - enter into contracts and joint venture agreement whether commercial or trading in nature - acquire, purchase, take, hold and enjoy movable or immovable property of every description; and - convey, assign, surrender, yield up, charge, mortgage, demise, lease, reassign, transfer or otherwise dispose of, or deal with, any movable or immovable property or any interest therein vested in the Board. - The objectives of the Board are— - to promote and develop the kenaf industry - to establish national objectives, policies and priorities for the orderly development and administration of the kenaf industry; - to regulate, control and co-ordinate all activities relating to the tobacco industry; and - to promote and develop other economic activities for persons involved in kenaf industry and tobacco industry
Malaysian Biofuel Industry Act 2007 (Act 666)	This Act provides for activities relating to the mandatory use of biofuel and licensing of activities relating to production, storage and trade and prescribes the type of biofuel and its percentage by volume to be blended in any fuel. The Act sets out procedures and requirements to apply for a licence and deals with the provisions relating to revocation or suspension of licences. The Act further provides for: powers relating to enforcement, investigation, seizure, arrest, etc.; offences; regulation making powers of the Minister; etc.
Malaysian Biofuel Industry (Industry) Regulations 2008	The Regulations further prescribe licence fees, the conditions to be imposed on licences, the power to limit the number of licences, the procedures regarding revocation and suspension of licences, and the procedures regarding appeals.
Malaysian Rubber Board (CESS) Order 1998 (Gazetted on 1 July 1998)	Imposed CESS to the manufacturers

table continues...

Cross Cutting	Objectives
Malaysian Cocoa Board (Incorporation) Act 1988 (Act No 343)	1. There is an established corporate body corporate by the name of "Malaysian Cocoa Board". 2. The Board shall have perpetual succession. 3. The Board may sue and be sued in its corporate name. 4. Subject to and for the purposes of this Act, and on such terms as it deems fit, the Board may (a) enter into contracts (b) in respect of movable and immovable property and interest in movable and immovable property, of every description— (i) acquire, purchase and take such property and interest; and (ii) hold, enjoy, convey, assign, surrender, yield up, charge, mortgage, demise, reassign, transfer, or otherwise dispose of or deal with, such property and interest vested in the Board.
Malaysian Palm Oil Board (Licensing) Regulations 2005	1. To regulate and coordinate all activities related to the palm oil industry 2. To check malpractices that are detrimental to the industry, and 3. To conduct quality control of palm oil products produced and traded.
Malaysian Palm Oil Board (Quality) 2005	1. To regulate the oil palm industry, including by the implementation of registration and licensing schemes 2. To prescribe the standards or grades of oil palm and oil palm products
Malaysian Palm Oil Board (Compound) 2005	• The offences under the Act and regulations that are specified in the Schedule may be compounded by the Director-General under subsection 71(1) of the Act.
Malaysian Rubber Board Act 1996 (Act No 551)	1. To promote and develop the rubber industry of Malaysia 2. To develop national objectives, policies and priorities for the orderly development and administration of the rubber industry of Malaysia. May enter into contract and acquire , purchase, take, hold, and enjoy movable and immovable property of every description.
Malaysian Rubber Board (Licensing) Regulations 1997 [Regulation Order (Amendment) 156/97]	1. To prohibit against buying or selling rubber without license 2. To prohibit against transporting rubber or rubber planting material without written authority 3. To prohibit accepting delivery of rubber planting materials without written authority
Malaysian Rubber Board (CESS) Order 1997 [Regulation Order (Amendment) 517/97]	• Imposed cess to the manufacturers
Cocoa (Licensing and Grading) Regulations 1991 [Regulation Order (Amendment) 198/91]	• To develop the cocoa industry in Malaysia to be well integrated and competitive in the global market. All cocoa bean producers, distributors, exporters, grinders and cocoa ingredient manufacturers and exporters in Malaysia are required to register and obtain the operating license related to their activities within the cocoa industry

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Cross Cutting	Objectives
Industrial Sector	
Minimum Energy Performance Standards (MEPS) for selected appliances in manufacturing	To improve energy efficient in Malaysia's Industrial Sector through removing barriers to efficient industrial energy use, and through creating a sustainable institutional capacity to provide energy efficiency sources, and a conducive policies, planning and research framework
The Industrial Energy Audit Guidelines	Removing barriers to industrial energy efficiency and energy conservation
Environmental Quality Act 1974	To prevent, abate, and control of pollution and enhancement of the environment
Environmental Quality regulations	To implement the protection of environment through proper waste treatment
Street, Drainage and Building Act 1974	To require the owner and occupier of buildings to keep adjacent private roads, public places, streets and building clean
Local Government Act 1976	It empowers the local government to execute laws related to the disposal of solid waste
Town and Country Planning Act 1976	It requires any buildings or lands used for solid waste management to seek planning permission
Action plan for a Beautiful and Clean Malaysia (ABC) 1988	Policy objective: to establish by year 2010 a municipal solid waste management system covering the whole of Malaysia and is uniform, cost effective, environmentally sound as well as practising socially acceptable procedures to enhance further the image of Malaysia in terms of its beauty and cleanliness.
Interim Privatisation Programme 1993	It allows private companies to manage/collect solid waste. Three companies were awarded to manage solid waste in the northern, southern, central regions of peninsular Malaysia and one company for East Malaysia
The National Policy on the Environment 2002	The objectives of the policy: 1. A clean, safe healthy and productive environment for present and future generations 2. Conservation of the country's unique and diverse cultural and natural heritage with effective participation from all sectors of the society 3. Sustainable lifestyles and patterns of consumption and production
National Strategic Plan for Solid Waste Management in Malaysia, NSP 2005	The establishment of a regulatory framework i.e development of legislation and institution; development of solid waste management facilities; establishment of infrastructure in waste minimisation and recovery (Formulated in 2002 and adopted in 2005)
Solid Waste and Public Cleansing Management Act 2007	It allows the management of solid waste under the federal government ; establishment of department of national solid waste management
Solid Waste and Public Cleansing Management Corporation Act 2007	Establishment of the Solid Waste and Public Cleansing Management Corporation with powers to administer and enforce the solid waste and public cleansing management laws and related powers
National Policy on Climate Change (2009)	KA25 - ST6: Integrate measures into policies, plans, programmes and projects in many areas including the waste management

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Cross Cutting	Objectives
Transportation sector	
Cabotage Policy	Under this policy, the shipping of goods and carriage of passengers from any port or place in Malaysia to another port or place in Malaysia including the exclusive economic zone must be by Malaysian registered vessels holding valid Domestic Shipping Licenses
Load Centering	- Port Klang, the premier port, is designated as the national load centre for both local and regional containers. This is to ensure sufficient critical mass at one port and subsequently make it an attractive destination for Main Line Operators (MLOs), thereby developing the port as a transshipment and distribution hub of the region. - The Port of Tanjung Pelepas is designated as the transshipment hub for containers.
Air Pollution Control for Malaysia Cities : transport and Industry	To develop and enforce existing and new emission standards, improve fuel quality, enabling integrated transport planning, developing strategies for social communication and participation, improve data collection and monitoring
Integrated Transport Information System (ITIS)	- To improve traffic flow by a traffic management system in the Klang Valley. The system comprises of two components namely the Advance Traffic Management Systems (ATMS) and Advance Travellers. - Information System (ATIS) that is used for traffic monitoring, accident and construction. - To alleviate/control increasing urban congestion, air pollution and safety problem through ITS assisted traffic management.
Go Lo-CO ₂	- To reduce carbon emission by usage of environment friendly modes of transport. - To raise public awareness on reducing carbon emission and reducing the number of cars on road travelling from the city of Kuala Lumpur to the Kuala Lumpur International Airports (KLIA) and the Low Cost Carrier Terminal (LCCT).
Project Green Planet	To initiate sustainability efforts by Kuala Lumpur International Airport (KLIA) as their Corporate Social Responsibility programme and to promote greater appreciation of environment and encourages activities that protect and preserve planet
Carbon Offset Scheme	Set to fund selected United Nations-sanctioned programs to protect rainforests in Malaysia and to reduce greenhouse gases and curb the onset of climate change. The money collected will be deposited in a trust fund set up by Forest Research Institute Malaysia; monitored by Ministry of Natural Resources and Environment
AWAS! program; Area-Watch and Sanction program.	The objectives of the program include area-wise inspection of emission norm non-compliant diesel vehicles and vehicles emitting excessive smoke for prohibiting usage thereof or subjecting to remedial measures when emissions are below higher limit

table continues...

Cross Cutting	Objectives
The Public Transportation Trust Fund (PTTF)	The fund was established with the savings the Government derived from the its reduction of subsidy for fuel prices
Government Transformation Programme (GTP) 2010	- To increase public transport modal share in Klang Valley, Penang and Johor Bahru, with an initial target of 25% by 2012 for Klang Valley. - To reduce traffic congestion, carbon emissions, noise pollution, and safety problems and significantly lowering fuel consumption attributed to the rapidly grown car population in the Klang Valley region.
National Policy on the Environment	To integrate environmental considerations into development activities in all related decision making process.
National Automotive Policy Framework	- To promote a competitive and viable automotive sector, in particular national manufacturer car - To become regional hub for manufacturing, assembly and distribution for automotive vehicles - To enhance value added and local capabilities in the automotive sector - To promote export oriented Malaysian manufacturers as well as component and part vendors - To promote competitive and broad-based Bumiputera participation in vehicle manufacturing, distribution and importation as well as component and parts manufacturing
National Biofuel Policy - Biofuel for Transport	Diesel for land and sea transport will be a blend of 5% processed palm oil and 95% petroleum diesel (B5)
National Green Technology Policy	Green Technology Policy is to provide direction and motivation for Malaysians to continuously enjoy good quality living and a healthy environment <i>Note:</i> <i>Transportation sector is one of the key areas – to incorporate green technology in the transportation infrastructure and vehicles, in particular, biofuels and public road transport.</i>
National Policy on Climate Change	To mainstream climate change through wise management of resources and strengthen institutional and implementation capacity to reduce negative impact of climate change <i>Note:</i> Key Action KA1-ST1, KA4-ST2, KA13-ST4, KA20-ST5, KA20-ST4, KA25 ST6 are all related to the transportation sector.

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Cross Cutting	Objectives
Budget 2011- Incentive.	1. The Mass Rapid Transit (MRT) in Greater KL (Klang Valley) will be implemented beginning 2011. This project, with an estimated private investment of RM40 billion, is expected to be fully completed by 2020. Upon completion, the utilisation rate of public transport is expected to increase to at least 40%. 2. Full import duty and 50% excise duty exemption was granted to franchise holders of hybrid cars as well as hybrid and electric motorcycles up to 31 December 2010. To further encourage ownership of hybrid cars, import duty and excise duty exemption will be extended until 31 December 2011 with excise duty to be given full exemption. 3. Tax exemption on income from trading of Certified Emission Reductions certificate to extend until year of assessment 2012. 4. Malaysia is committed to reducing carbon emission intensity to preserve the environment. For this purpose, the Government will implement among others, the Programme on Blending of Biofuels with Petroleum Diesel (B5 Programme) on a mandatory basis beginning in Putrajaya, Kuala Lumpur, Selangor, Negeri Sembilan and Melaka in June 2011 5. The Government will also implement the Feed in Tariff (FiT) mechanism under the Renewable Energy (RE) Act, to allow electricity generated from RE by individuals and independent providers to be sold to electricity utility companies. 6. RM6.9bil is allocated to implement basic infrastructure such as water and electricity supply as well as rural roads. 7. Build and upgrade rural roads in Sabah and Sarawak with an allocation of RM2.1bil and RM696mil in Peninsular Malaysia.

table continues...

Cross Cutting	Objectives
LULUCF Peninsular Malaysia	
National Policy on Biological Diversity, 1998	1. To optimise economic benefits from sustainable utilisation of the components of biological diversity 2. To ensure long-term food security for the nation 3. To maintain and improve environmental stability for proper functioning of ecological systems 4. To ensure preservation of the unique biological heritage of the nation for the benefit of present and future generations 5. To enhance scientific and technological knowledge, and educational, social, cultural and aesthetic values of biological diversity 6. To emphasize biosafety considerations in the development and application of biotechnology
National Forestry Act, 1984	• To conserve and manage the nation's forest based on the principles of sustainable management • To protect the environment as well as to conserve biological diversity, genetic resources, and to enhance research and education
Environmental Quality Act, 1974	• For prevention, abatement, control of pollution and enhancement of the environment, and purposes connected therewith
Aboriginal Peoples Act, 1954	• Establishment of Orang Asli Areas and Orang Asli Reserves, it also grants the state authority the right to order any Orang Asli community to leave - and stay out of - an area
Occupational Safety and Health Act, 1994	• To promote and encourage occupational safety and health awareness among workers and to create organization along with effective safety and health measures
Water Act, 1920	• To protect and conserve rivers and water sources from degradation and pollution • To control over development in water
Pesticides Act, 1974	• To control manufacture, sale and storage of pesticides in the country; • To ensure that pesticides are effective as claimed on the label; • To control adulteration with respect to its contents, concentration of active ingredients, efficacy and other characteristic of the pesticides; • To control pesticide residues in food for local use and also for export; and • To control pesticide hazards to users, operators, the public, domestic animals, water sources and the environment (Department of Agriculture 1989)
Aboriginal Peoples Act, 1954	• Establishment of Orang Asli Areas and Orang Asli Reserves and it also grants the state authority the right to order any Orang Asli community to leave - and stay out of - an area
Occupational Safety and Health Act, 1994	• To promote and encourage occupational safety and health awareness among workers and to create organization along with effective safety and health measures

table continues...

Cross Cutting	Objectives
Water Act, 1920	- To protect and conserve rivers and water sources from degradation and pollution - To control over development in water
Industrial Relations Act, 1967	- An Act to provide for the regulation of the relations between employers and workmen and their trade unions and the prevention and settlement of any differences or disputes arising from their relationship and generally to deal with trade disputes and matters arising there from. - A piece of social legislation enacted with the object of attaining social justice and industrial peace, demands practical and realistic interpretation wherever necessary, for the purpose of maintaining good relationship and fair dealings between employers and workers and their trade union, and the settlement of any differences or disputes from their relationship.
National Agricultural Policy, 1998-2010	- The maximisation of income through the optimal utilisation of resources in the sector - This includes maximising agriculture's contribution to national income and export earnings as well as maximising income of producers
National Policy on Environment, 2002	A clean safe, healthy, and productive environment for present and future generations. Conservation of the country's unique and cultural and natural heritage with active participation by all sectors of society. Sustainable lifestyles and patterns of consumption and production
Factories and Machineries Act, 1967	- Focus on control of factories & machinery - Registration & inspection of machines - Less provision for health
Sabah	
State Forest Policy, 1954	- To declare sufficient land that is strategically located throughout Sabah as Permanent Forest Reserves in accordance with the concept of rational land use to ensure: - Sound climatic and physical conditions of the State, maintenance of watershed, soil fertility and environmental quality, conservation of nature and biodiversity, and minimal flood damage and soil erosion; such forest areas are classified as PROTECTION FORESTS. - Perpetual supply of forest products for subsistence and industrial uses; such forest areas are classified as PRODUCTION FORESTS. - Conservation of adequate forest areas for recreation, education and research; such forest areas are classified as AMENITY FORESTS - To manage the Permanent Forest Reserves so as to maximise social, economic and environmental benefits for the State and its people in accordance with the principles of sustainable forest management. - To pursue forest development programmes through forest conservation and rehabilitation operations in accordance with approved silvicultural practices to optimise productivity of the Permanent Forest Reserves.

table continues...

Cross Cutting	Objectives
	d. To ensure proper utilisation of forest resources from land that is not classified as Permanent Forest Reserves through careful planning and in co-operation with land development agencies before the said land is alienated in order to maximise the returns for the people by means of suitable harvesting and processing methods. e. To promote efficient harvesting and utilisation of all types of forests and to stimulate the development of appropriate forest-based industries so as to maximise resource utilisation, create employment opportunities and generate foreign exchange earnings. f. To encourage the development of trade in forest products. g. To encourage Bumiputera participation in forest and wood-based industries. h. To undertake and support intensive research programmes in forestry development aimed at achieving optimum yield and returns from harvesting and utilisation of the Permanent Forest Reserves as well as maximising the return of investment from forestry development activities. i. To undertake and support comprehensive training programmes in forestry at all levels to provide adequate trained personnel to meet the needs of the forestry sector. j. To encourage private sector participation at all levels of forestry research and training with a view to enhancing professionalism in forestry and forest industries. k. To foster better understanding among the general public of the multiple values of the forest through education and public awareness programmes. l. To utilise information and communication technology for the efficient management of the State's forest resources. m. To foster close relationship and co-operation at the international level to enhance forest development and management of the State's forest resources.
National Policy on Biological Diversity, 1998	a. To optimise economic benefits from sustainable utilisation of the components of biological diversity b. To ensure long-term food security for the nation c. To maintain and improve environmental stability for proper functioning of ecological systems d. To ensure preservation of the unique biological heritage of the nation for the benefit of present and future generation e. To enhance scientific and technological knowledge, and educational, social, cultural and aesthetic values of biological diversity f. To emphasize biosafety considerations in the development and application of biotechnology

table continues...

Cross Cutting	Objectives
Forest Enactment, 1968	The gazetement of forest reserves, their use and management as well as for control of cutting and removal of forest produce by "State Land"
Biodiversity Enactment, 2000	The guideline to accessing biological resources , legal proceedings, offences and penalties for violating the access procedures and for the unauthorised removal of any biological resources out of the State
Environmental Quality Act, 1974	Prevention, abatement, control of pollution and enhancement of the environment, and for purposes connected therewith
Pesticides Act, 1974	Same as in Peninsular Malaysia
Sarawak	
Statement of Forest Policy, 1954	a. To optimise the utilisation of the forest resources; b. To regulate and ensure that harvesting is done in a sustainable manner; c. To minimise damage to residual stand and the environment; d. To rehabilitate harvested forests and improve the stocking of valuable timber species by proper silvicultural techniques; e. To maintain a 25 years rotational cycle for the dipterocarp forests and 45 years for the peat-swamp forests.
Environmental Quality Act, 1974	Prevention, abatement, control of pollution and enhancement of the environment, and for purposes connected therewith
A Master Plan for Wildlife in Sarawak, 1996	a. To formulate a comprehensive, cross-sectoral wildlife strategy for Sarawak, which will enable Sarawak to manage and conserve its native wildlife populations in perpetuity. The strategy aims to balance and integrate the conservation of wildlife and natural resources with the economic and development needs of state; b. To propose a series of recommendations on how the strategy can be put into practice; c. To compile these into a document which is user-friendly for use by Government and relevant personnel in the private sector.
Public Parks and Greens Ordinance, 1993	To make provisions for the control and management of any area of land which has been declared to be a special area to enhance the environment of that area and to provide for the regulating of proper planning in the State for the preservation and protection of greens
The Forests (Planted Forests) Rules, 1997	To encourage the development of commercial forest plantations and has set a target of 1.0 million hectares for forest plantations to be established by 2020
Natural Resources and Environment (Fire Danger Rating System) Order, 2004	To assist the plantation sector in land clearing and fire management

Adapted from: Various Government Ministries and Agencies.

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