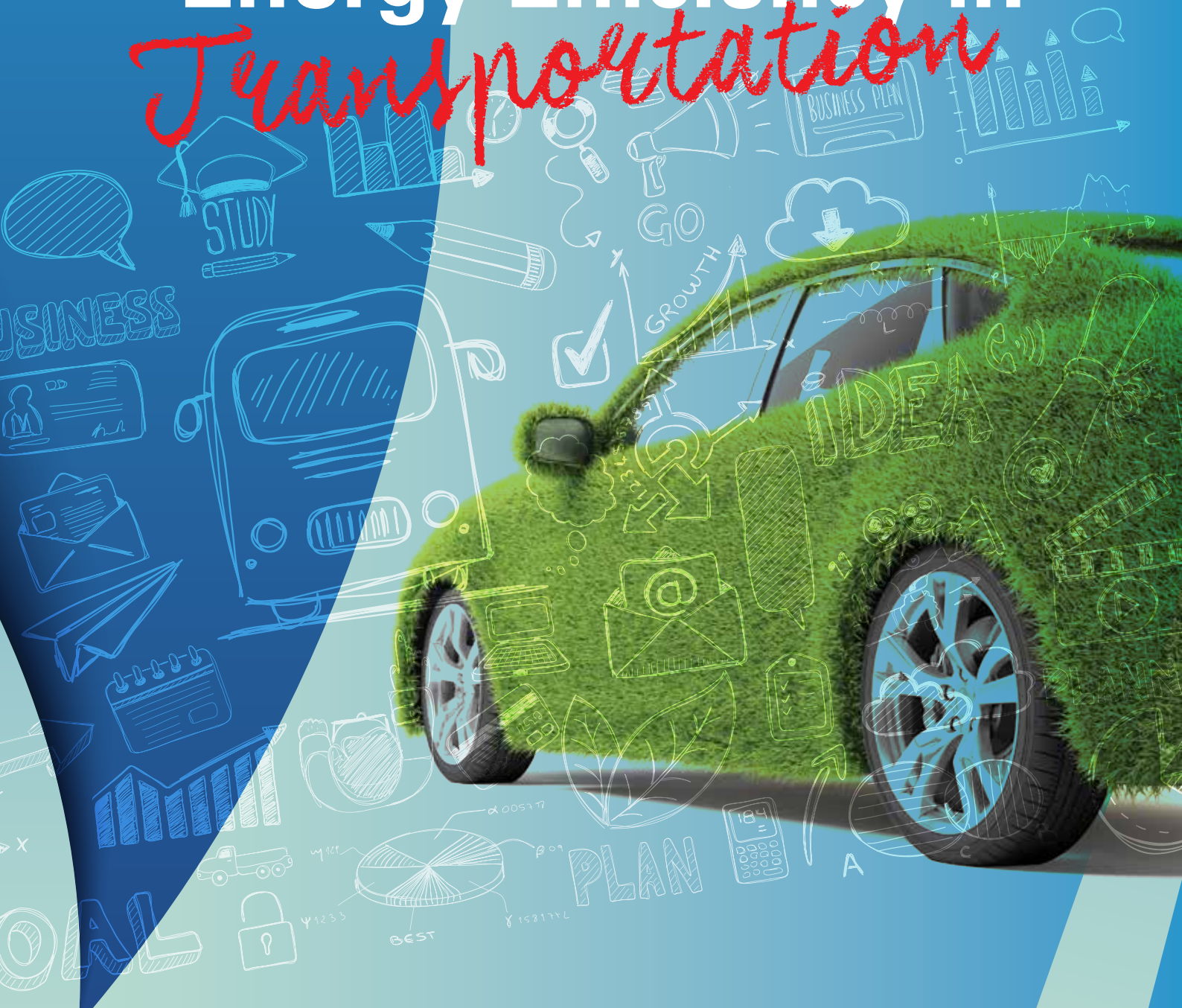


Advisory Report on Energy Usage and Energy Efficiency in

Transportation





© Academy of Sciences Malaysia 2015

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise without prior permission of the Copyright owner.

The views and opinions expressed or implied in this publication are those of the author and do not necessarily reflect the views of the Academy of Sciences Malaysia.

Published by:

Academy of Sciences Malaysia
Level 20, West Wing, MATRADE Tower,
Jalan Sultan Haji Ahmad Shah,
off Jalan Tuanku Abdul Halim,
50480 Kuala Lumpur, Malaysia
Phone : +6 (03) 6203 0633
Fax : +6 (03) 6203 0634
admin@akademisains.gov.my

ASM Advisory Report 2; Aug 2015

Perpustakaan Negara Malaysia

Cataloguing-in-Publication Data

ADVISORY REPORT ON ENERGY USAGE AND ENERGY

EFFICIENCY IN TRANSPORTATION

ISBN 978-983-2915-26-3

1. Electric vehicles. 2. Transportation--Energy consumption.

3. Energy consumption

629.2293

Table of Contents

ACKNOWLEDGEMENT	i
FOREWORD	iv
PREFACE	v
EXECUTIVE SUMMARY	vi
LIST OF ACRONYMS	x
1 INTRODUCTION	
1.1 Energy in Transportation	1
1.1.1 Energy Usage - Global Outlook	1
1.1.2 Energy Usage - Current Status in Malaysia	3
1.1.3 Energy Efficiency	7
2 ENVIRONMENT	
2.1 Global Outlook	9
2.2 Environmental Impact of Transportation in Malaysia	11
2.2.1 Road	11
2.2.2 Rail	14
2.2.3 Maritime	14
2.2.4 Aviation	18
2.3 Effect of Energy Usage and Efficiency in Transportation on the Environment	20
2.4 Challenges	23
3 POLICY	
3.1 Global Outlook	27
3.1.1 Fuel Economy and Greenhouse Gases Standards	27
i) Light Duty Vehicles	27
ii) Heavy-Duty Vehicles	29
iii) Rail	30
iv) Maritime	30
v) Aviation	31
3.1.2 Labelling	31
3.1.3 Renewable Fuel Policies	34
3.1.4 Low Carbon Fuel Standards	34
3.1.5 Vehicle Taxes and Incentives	35
3.2 Current Status in Malaysia	36
3.2.1 Fuel Quality and Emission Standards	37
3.2.2 Renewable Fuel Policies	38
3.2.3 Vehicles Tax and Incentives	38
3.3 Challenges	39
3.4 Recommendations/Action Plans	39

4	TECHNOLOGY	
4.1	Global Outlook	45
4.1.1	Fuel Technology	45
i)	Hydrogen Fuel	45
•	United States Initiatives on Hydrogen	47
•	Hydrogen Fuel Cell Status and Barriers	48
ii)	Natural Gas	49
•	World Reserve and Consumption of Natural Gas	50
•	Natural Gas Status and Barriers	52
•	Heavy and Medium Duty Engine Technologies	53
•	Light Duty Vehicles	54
•	Maritime	54
•	Rail	54
iii)	Bio-Methane/ Biogas	54
iv)	Biofuels	55
•	Current Status and Barriers	56
4.1.2	Electrification of Transportation	59
i)	Electric Vehicle Configuration and Current Status	60
ii)	Electric Vehicle Key Technologies	60
•	Electric Motor	60
•	Power Electronics	61
•	Energy Storage System	62
•	Battery Charging	62
4.1.3	Revolutionary Transportation System	63
i)	Improving Vehicle Efficiencies	66
4.2	Current Status in Malaysia	67
4.2.1	Fuel Technology	67
i)	Fuel Cell Technology	67
ii)	Natural Gas	69
iii)	Biodiesel	69
iv)	Biomass/Bio-Natural Gas	71
4.2.2	Energy Efficient Vehicles	74
4.2.3	Vehicle Electrification	75
4.2.4	Urban Transportation Infrastructure	80
i)	Mass Rapid Transit	80
ii)	Bus Rapid Transit	80
4.3	Recommendations / Action Plans	81
5	SUMMARY AND CONCLUSIONS	
5.1	Summary	91
5.2	Conclusion	93
	REFERENCES	96
	APPENDIX	99



Acknowledgement

ASM Task Force

Academician Tan Sri Datuk Ir (Dr) Hj Ahmad Zaidee Laidin FASc
Co-Chairman of Task Force

Professor Dr Nasrudin Abd Rahim FASc
Co-Chairman of Task Force

Academician Datuk Fateh Chand FASc

Professor Dr Zahari Taha FASc

Professor Dr Hew Wooi Ping, UM

Ir Lalchand Gulabrai FASc

Associate Professor Dr Mohd Amran b Mohd Radzi, UPM

Associate Professor Dr Zulkifilie Bin Ibrahim, UTEM

Professor Ir Dr Abdul Halim bin Mohamed Yatim, UTM

Mr Mohamad Madani Sahari, MAI

Ir Dr Tuan Ab Rashid bin Tuan Abdullah, UNITEN

Dato' Rohaini Binti Mohd Yusof, MOT

Mr Abd Ghafar Yusof, MOT

Professor Emeritus Dato' Dr Muhammad Yahaya FASc

Associate Professor Dr Halim Bin Setan, UTM

Writers

Mr Anwar b PP Abdul Majeed, UMP

Dr Che Hang Seng, UM

Mr Wan Noraishah Wan Abdul Munim, UM

Coordinated & Managed by

Mr Mohd Ikhwan Bin Abdullah, ASM
Ms Nitia Samuel, ASM

Workshop Participants

NAME	ORGANISATION
Datuk Ir Peter Lajumin	Tawau Green Energy
Dr Kismet Hong Ping	Universiti Malaysia Sarawak
Professor Ir Dr Andrew Ragai Henry Rigit	Universiti Malaysia Sarawak
Ms Ilham Fadilah Binti Sunhaji	PEMANDU
Mr Endry Lim Zhen Wen	PEMANDU
Ir Dr Mohamad Puad Haji Abu	Malaysia Nuclear Agency
Mr Rosli Darmawan	Malaysia Nuclear Agency
Mr Mohd Nazmi Bin Mohd Nur	Malaysia Automotive Institute
Mr Mohd Khairul Ainol Jamal	Greentech Malaysia
Dr Suzana Yusup	Universiti Teknologi Petronas
Dr Umer Rashid	Universiti Putra Malaysia
Ms Michelle Kwa	ISIS Malaysia
Datin Badriyah Ab Malek	Economy Planning Unit
Mr Mohd Sukri b. Mat Jusoh	Economy Planning Unit
Dr Mohammed Shahrin Bin Umar	Economy Planning Unit
Mr Jeya Seelan A/L Subramaniam	Economy Planning Unit
Mr Ahmad Zuhairi b Muzakir	Economy Planning Unit
Dr Ahmad Safuan Bujang	MARDI
Datuk Professor Dr Muhammad Yahaya	Universiti Kebangsaan Malaysia
Dr Lim Boon Han	Universiti Tunku Abdul Rahman
Mr Syahmi Farhan Mohamed	Rapid Rail Sdn. Bhd.
Mr Mohamad Khairol Bin Khalid	MOSTI
Ms Nabilah Mohd Taha @ Talhah	MOSTI
Ms Yazlin Salfiza Mohd Yazid	Lembaga Lebuhraya Malaysia
Mr Faiz Fadzil	KeTTHA
Mr Mohd Rezuan	Universiti Malaya

Dr Tan Beng Hoe	NRE
Ms Siti Fatirah Jaladin	Malaysia Automotive Institute
Mr Paul Wong	KeTTHA
Mr Nur Muhamad Muhd Jamil	Ministry of Transport
Dr Istas Fahrurrazi Nusyirwan	Universiti Teknologi Malaysia
Ms Cheryl Rita Kaur	MIMA
Abdul Salim Shah Abdul Aziz	KTMB
Professor Dr Omar Bin Yaakob FASc	Universiti Teknologi Malaysia
Dr Irwin Sulaeman	International Islamic University of Malaysia

The task force team would like to thank all those who participated and contributed to this advisory report.

Foreword

The Academy of Sciences Malaysia (ASM) has been entrusted with the mandate to be a “Thought Leader” in the Science, Technology and Innovation (STI) arena; and we consider this an immense responsibility to our society and nation. The Academy translates this mission into action by undertaking strategic STI studies and delivering programmes that mobilise a wide spectrum of expertise not only within the Academy, but also in its network of prominent international and local linkages. ASM is committed to providing the highest quality of scientific, intellectual and strategic input concerning global challenges and national priorities.

The transport infrastructure is a key reflection of a nation’s economic development. However, globally, the transportation sector is also a major contributor to climate change since transport-related greenhouse gas emissions are expected to double by 2050. Therefore, low-carbon and climate-resilient sustainable transport must be prioritised. This calls for robust policies and private sector participation driven by good governance. In cognisance of the gravity of this issue, ASM has established a Task Force to deliberate on the key aspects and produce this “Advisory Report on Energy Usage and Energy Efficiency in Transportation”.



Tan Sri Dr Ahmad Tajuddin Ali FASc

In developing this advisory report, ASM has engaged various experts and stakeholders from energy and transportation sectors. I hope the highlighted issues and recommendations in this advisory report would benefit policy makers, academicians as well as industry players to harness STI towards sustainable solutions for the transportation sector. Considering that the transportation sector is one of the most energy intensive sectors in the country, hence there is a need to power this sector through more clean energy initiatives to safeguard the environment. This will also enable Malaysia to fulfill its commitment at international conventions such as the 15th Copenhagen Climate Change Conference (COP15) to significantly reduce carbon dioxide emission levels by 2020.

I would like to congratulate the ASM Task Force on Energy Usage and Energy Efficiency in Transportation under the leadership of the Co-chairs, Academician Tan Sri Dato’ Ir (Dr) Hj Ahmad Zaidee Laidin FASc and Professor Dr Nasrudin Abd Rahim FASc on this timely advisory report. I hope this advisory report would catalyse concerted effort towards reducing carbon footprint in the transportation sector.

President, Academy of Sciences Malaysia

Preface by Co-Chairs

According to the 11th Malaysia Plan (11th MP), the transportation sector is the second most energy-consuming sector in the country, after the industrial sector. The transportation sector accounts for 40 per cent of total energy consumption in Malaysia. It relies almost completely (e.g. up to 98 per cent) on petroleum products.

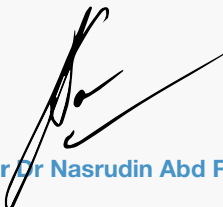
The objectives of this report are to identify the current status of Malaysia's transport energy usage and efficiency as well as recommend appropriate measures for improvement. In order to have a holistic view of the issues surrounding energy usage and energy efficiency in transportation, two stakeholder consultation workshops were conducted by the Academy Sciences Malaysia (ASM). The findings and the recommendations of this report are based on the deliberations of the workshops as well as analysis of relevant reports.

This report covers the environment, policy and technology aspects related to energy usage and efficiency in transportation. The environment section outlines the impact of transport energy usage and energy efficiency on the environment, while the recommendations for mitigation actions are given under the policy and technology sections. Current status from both global and local perspectives is also provided along with some propositions in the Malaysian context. Overall, this report advocates for requisite action to be taken via the adoption of new policies and development of new technologies.

On behalf of the Academy of Sciences Malaysia (ASM), we wish to thank all members of the Task Force and all stakeholders who participated in the consultative workshops for their valuable input and insights. The contribution of each one who has been involved in producing this report in one way or another is highly appreciated. It is hoped that this report will serve as a useful reference towards realising sustainable transport in Malaysia.



Academician Tan Sri Dato' Ir (Dr)
Hj Ahmad Zaidee Laidin FASc



Professor Dr Nasrudin Abd Rahim FASc

Co – Chairs
ASM Task Force on Energy Usage and Energy
Efficiency in Transportation

Executive Summary

This report provides an overview on the issue of energy usage and energy efficiency in the transportation sector. Based on findings obtained from two stakeholder workshops conducted by the Academy of Sciences Malaysia, this report summarises the current status and recommends further actions for improving the usage of transport energy and energy efficiency in Malaysia. The report is divided into three sections namely environment, policy and technology. The environmental section outlines the impact of transport energy usage and energy efficiency on the environment, while the recommendations for mitigation actions are given under the policy and technology sections.

From this report, it can be concluded that action must be taken in order to improve the current energy usage pattern in the transportation sector via the adoption of new policies and the development of new technologies. In terms of policy, a master transport policy that considers energy usage and energy efficiency is recommended, alongside policies for fuel and emission standards, incentives for phasing out inefficient vehicles as well as energy usage and fuel efficiency labelling policies for vehicles. At the same time, policies to support future vehicle technologies, particularly policies from the internet for vehicles, electric vehicles and biofuel productions are also suggested. From the technological perspective, this report highlights the need to develop technologies for electric vehicles (EVs) together with energy efficient vehicles (EEVs). The development of enabling technologies for EVs and alternative fuels namely biofuels and hydrogen fuels is recommended, as the technology steps forward for improving transport energy usage and energy efficiency.

Below are the proposed recommendations with the timelines in terms of Policy:

PROPOSED RECOMMENDATIONS / ACTION PLANS	STRATEGIES		
	2020	2035	2050
Integrated Transport Master Plan to address the development of the transportation system in Malaysia in a holistic manner. Stakeholders: MOT, SPAD, KeTTHA, TNB/SEB, DOE etc.	X		
Reduce unnecessary energy loss		X	
Action plans should be prepared for implementing and monitoring the policies Stakeholders – all relevant agencies	X		
Internet of Vehicle (IoV) policy. Stakeholder – MITI, MOT		X	
Electric Vehicle Policy [2020] Stakeholders: MAI, MOT	X		
Malaysia should proceed at its own pace for higher emission standard, on par with Europe and USA standards. Stakeholders: KeTTHA, MOT	X		
Continue development of biofuel as a source of energy for transportation. Stakeholders: KeTTHA, MOT	X		
Tax and incentive policy to phase out energy inefficient vehicles. Stakeholders: MOF	X		
Implement mandatory energy usage and fuel efficiency labelling for vehicles. Corresponding enforcement policy should be outlined. Stakeholders: MITI & MOT	X		

Below are the proposed recommendations with timelines in terms of Technology development:

PROPOSED RECOMMENDATIONS / ACTION PLANS	STRATEGIES		
	2020	2035	2050
Hydrogen and Fuel Cell R&D on hydrogen production. (non –electrolysis)	X		
Feasible non-electrolysis processes may be materialised, that in turn can drive fuel cell development (from automobile manufacturers)		X	
Transfer of technology to the application vehicle		X	
Hydrogen production and distribution infrastructure are available at a plausible scale.			X
Locally manufactured Fuel Cell vehicle should be available. Application on LDV.			X
Natural Gas & Bio-Methane/ Biogas Wider distribution system – to cater for the storage issues.	X		
Non-fossil based R&D	X		
Expanded network, non- fossil fuel sources should be expanded		X	
R&D in methane purification		X	
Application on HDVs and perhaps further expanded to LDVs			X
Replace conventional NG with biogas/syngas.			X
Electrification of Vehicles Status Iriz.EV may take off	X		
More electric busses should be available – cater for public transportation	X		
Regulating of online monitoring system as standard/ compulsory vehicle requirement	X		
Hybrid R&D		X	
Hybrid should take off			X
Autonomous pod- like on tracks (long term), crash free – safety aspects, electrified, efficient due to light weight			X
Ultimately the use of LDV akin to park and ride to cater for the general public (pod like) – last mile utilisation –reduce congestion			X

Key Enabling Technologies The identification of viable technology to be developed by means of technology scanning and assessment on technologies that have yet to be locally developed	X		
Knowledge transfer of the suitable technologies to be developed		X	
Multi-national EV component manufacturer should be invited to invest locally.		X	
Local development and assembly of the identified technologies			X
Energy Efficient Vehicles (Conventional ICE) The efficiency gain for existing engine technology may possibly be gained through the use of advanced cleaner propulsion technologies such as the implementation of direct injection (DI) system, emission reduction by 3-way catalytic converter and diesel particulate filter (DPF), as well as the improvement of existing combustion efficiencies through optimum engine control strategies which include the adaptation of alternative fuel.	X	X	X
To increase the number of ICOE	X	X	X

List of Acronyms

L/100 km - Litres per 100 Kilometres	CAFC - Company Average Fuel Consumption
mpg - Miles per Gallon	CBU - Complete Built Up
FEN - First Energy Networks	CKD - Complete Knocked Down
2DS - 2 Degree Scenario	CNG - Compressed Natural Gas
4DS - 4 Degree Scenario	COPERT 4 - Computer Programme to estimate Emissions from Road Traffic
6DS - 6 Degree Scenario	CDA - Continuous Descent Approach
ANG - Adsorbed Natural Gas	CAFE - Corporate Average Fuel Economy
AARC - Advanced Material Research Centre	DOE - Department of Environment
ATN - Advanced Transit Networks	DOT - Department of Transportation
AC - Alternating Current	DPF - Diesel Particulate Filter
ASEAN - Association of Southeast Asian Nations	bio-SG - diesel and biosynthetic gas
AFA - Asean Framework Agreement	DMU - Diesel Multiple Unit
APU - Auxiliary Power Units	DC - Direct current
AFE - Average Fuel Economy	DI - Direct Injection
BEV - Batteries Electric Vehicle	DMT - Dual Mode Transit
Bcf/d - Billion Cubic Feet per Day	EPU - Economic Planning Unit
BtL - biomass-to-liquids	EB1M - Electric Bus 1 Malaysia
BSEC - Brake Specific Energy Consumption	eMobility - Electric Mobility
BET - Bus Expressway Transit	EMU - Electric Multiple Unit
BRT - Bus Rapid Transit	EV - Electric Vehicle
CARB - California Air Resources Board	EVSE - Electric Vehicle Supply Equipment
CCS - Carbon Capture and storage	EC - Energy Commission
CO ₂ - Carbon Dioxide	EEDI - Energy Efficiency Design Index
CO ₂ - Carbon Emission	EEV - Energy Efficiency Vehicle
CO ₂ /km - km Carbon Emissions per Kilometre	ETP 2014 - Energy Technology Perspectives 2014
CEV - Carbon Emissions-based Vehicle	EPA - Environmental Protection Agency
CO - Carbon Monoxide	ETS - Electric Train Services
SCR - Selective Catalytic Reduction	EU ETS EU - Emissions Trading System
COMOS - Cohesive Mobility Solution	ERTRAC - European Road Transport Research Advisory Council
CAEP - Committee on Aviation Environmental Protection	

EU - European Union	IPM - Interior Permanent Magnet
FAST - Facility for Accelerated Service Testing	IATA - International Air Transport Association
FER - Fertilizer Use	ICAO - International Civil Aviation Organisation
FTV - Fleet Testing Vehicles	IEA - International Energy Agency
FC - Fuel Cell	IEEC - International Energy Efficiency Certificate
FCEV - Fuel Cell Electric Vehicle	IMO - International Maritime Organisation
FCV - Fuel Cells Vehicles	IoV - Internet of Vehicle
FELS - Fuel Economy Labelling Scheme	JPJ - Road Transport Department
FEV - Full Electric Vehicle	KTM - Kereta Api Tanah Melayu
g/km - Gram per Kilometre	KTMB - Kereta Api Tanah Melayu Berhad
GaN - Gallium Nitride	km/L - kilometres per litre
gCO ₂ /km - Gram of Carbon Emission per Kilometre	kW-hrs/100 mi - kiloWatt-hours per 100 miles
GOV - Governance Quality	KL - Kuala Lumpur
GTP - Government Transformation Programme	kW - Kilo watt
GHG - Greenhouse Gas	SPAD - Land Public Transport Authority
GDP - Gross Domestic Product	LPKP - Lembaga Perlesenan Kenderaan Perdagangan
GNI - Gross National Income	LDV - Light Duty Vehicle
GVW - gross vehicle weights	LNG - Liquefied Natural Gas
GRT - group rapid transit	LCFS - Low Carbon Fuel Standards
HD - High Duty	LEV II - Low Emission Vehicle
HPDI - High Pressure Direct Injection	LRT - Light Rail Transit
HDV - High Duty Vehicle	MAA - Malaysian Automotive Association
HSR - High Speed Rail	MAI - Malaysian Automotive Institute
HEMS - home energy management system	MESITA - Malaysian Electricity Supply Industries Trust
HPF - hot press forming	Account
HEV - Hybrid electric vehicle	Greentech Malaysia - Malaysian Green Technology
HC - hydrocarbons	Corporation
H ₂ - Hydrogen	MNGV - Malaysian NGV
HFP - Hydrogen and Fuel-Cell Technology Platform	MC - marine captures
H ₂ ICE - Hydrogen in Internal Combustion Engine	MBM - Market Based Measure
HCNG - Hydrogen-CNG	MRT - Mass Rapid Transit
HVO - Hydro-treated Vegetable Oil	MOSFET - Metal Oxide Semiconductor Field-Effect
ICoE - Industry Centre of Excellence	Transistor
IDA - Innovation and Development Action	CH ₄ - methane
IGBT - Insulated Gate Bipolar Transistors	MPG - Miles per Gallon

MOF - Ministry of Finance	pENV - Proportional Composite Environmental
KeTTHA - Ministry of Energy, Green Technology and Water	PEM - Proton Exchange Membrane
MITI - Ministry of International Trade and Industry	QL - Queensland
MOT - Ministry of Transport	REEV - Range Extender Electric Exora
MY - Model Years	RFS2 - Renewable Fuel Standard
MOSTI - Ministry of Science, Technology and Innovation	RNG - Renewable Natural Gas
NAP - National Automotive Policy	R&D - Research and Development
NBS 2020 - National Biomass Strategy	RTG - Rubber Tyred Gantry
NHTSA - National Highway Traffic and Safety Administration	SCORE - Sarawak Corridor of Renewable Energy
NKRA - National Key Results Areas	SEB - Sarawak Energy Berhad
NPP 2 - National Physical Plan 2	SESB - Sabah Electricity Sdn Bhd
NFL - natural forest loss	SEEMP - Ship Energy Efficiency Management Plan
NG - Natural Gas	SiC - Silicon Carbide
NGVP - Natural Gas for Vehicles Program	SAE - Society of Automotive Engineering
HBC - natural habitat conversion	SOx - Sulfur Oxides
NSW - New South Wales	SI - Spark Ignited
NOx - nitric oxide and nitrogen dioxide	SUV - Sports Utility Vehicles
N2O - nitrous oxide	SVO - Straight Vegetable Oil
OECD - Organisation for Economic Co-operation and Development	SECAs - Sulphur Emission Control Areas
OEM - Original Equipment Manufacturer	SynRM - Synchronous Reluctance Motor
O3 - Ozone	SNG - Synthetic Natural Gas
POME - palm oil mill effluent	TWB - Tailor Welded Blank
PM - particulate matter	TNB - Tenaga Nasional Berhad
PRT - personal rapid transit	TCF - Trillion Cubic Feet
PGNV - PETRONAS NGV	UMPEDAC - Universiti Malaya Power Energy Dedicated Advanced Centre
PV - photovoltaic	UK - United Kingdom
PHEV - Plug-in hybrid electric vehicle	UN - United Nation
PD - Population Density	US - United States
PGR - Population Growth Rate	UM - Universiti Malaya
PISI - Engines Port Injected Spark Ignited	UPM - Universiti Putra Malaysia
PME - Produces Methyl Esters	UTP - Universiti Teknologi PETRONAS
PTHR - Proportion of Threatened Species	UKM - University Kebangsaan Malaysia
	UTM - Universiti Teknologi Malaysia
	VOCs - Volatile Organic Compounds
	WTP - Water Pollution

WG - Working Group

WBCSD - World Business Council for Sustainable
Development

WEO - World Energy Outlook

ZET - Zero Emission Transport



Introduction

1.1 Energy in Transportation

1.1.1 Energy Usage - Global Outlook

The energy consumption throughout the globe is expected to increase dramatically, especially amongst emerging economies in the coming years (GTS 2050). As of 2011, transportation accounted for 18 %, which was the third largest consumption item after conversion losses (28%) and industrial usage (22%), as illustrated in Figure 1.1 (International Energy Agency. 2014). The energy consumption for transportation had increased by 25 % within a decade, with road transport constituting approximately 75% of the energy consumed, as stated by the IEA (International Energy Agency. 2014). Petrol (gasoline) is by far the largest source of energy for transport followed by diesel (Figure 1.2).

■ Transportation ■ Residential ■ Industry ■ Commercial
■ Non-energy use ■ Other end-use ■ Conversion losses ■ Distribution losses

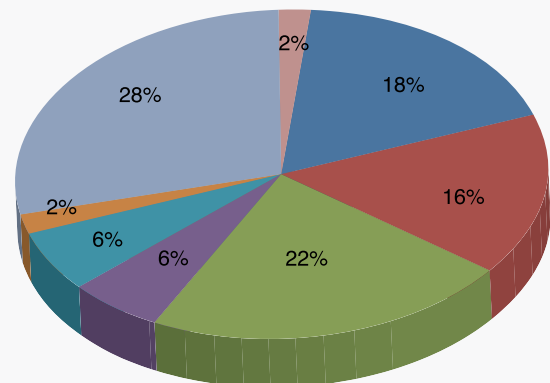


Figure 1.1 Primary energy consumption by sector

Source: International Energy Agency 2014

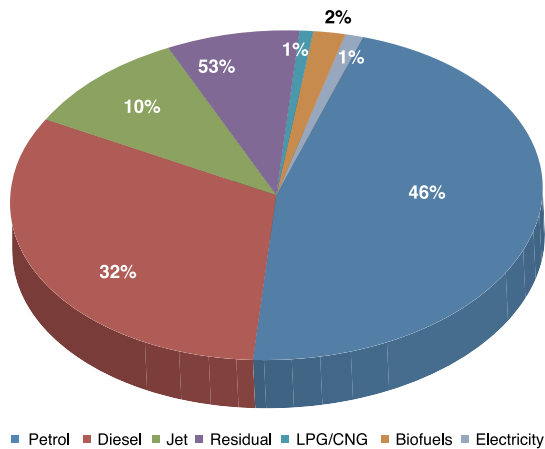


Figure 1.2 Transport energy by source, for year 2010

Source: International Energy Agency 2014

The inherent growth in global transport energy usage is strongly correlated with the global economic and population growth. According to the International Monetary Fund, the global average real Gross Domestic Product (GDP) growth over the span of approximately four decades (1980 to 2019) is 3.65 % p.a. (Figure 1.3). As of August 2014, the CIA World Fact Book has recorded that the global population grew as much as 1.064 %. The United Nations estimates the world's average annual population growth at 0.9 %, forecasting the world's population to be 9.2 billion by 2050. The increase in both GDP, as well as population growth, are often associated with the increase in vehicular ownership particularly Light Duty Vehicles (LDVs) (Figure 1.4), hence causing the rise in transport energy consumption, particularly with regard to road transport.

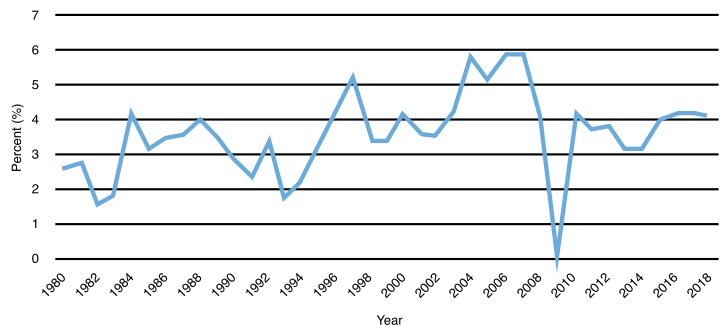


Figure 1.3 Annual growth outlook in real GDP

Source: IMF 2014

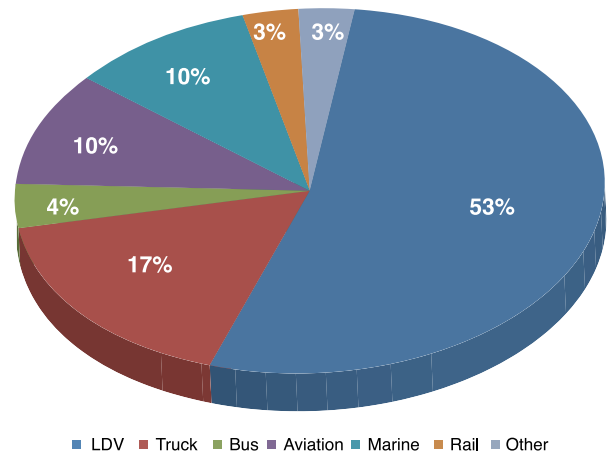


Figure 1.4 Transport energy by mode

Source: International Energy Agency 2014

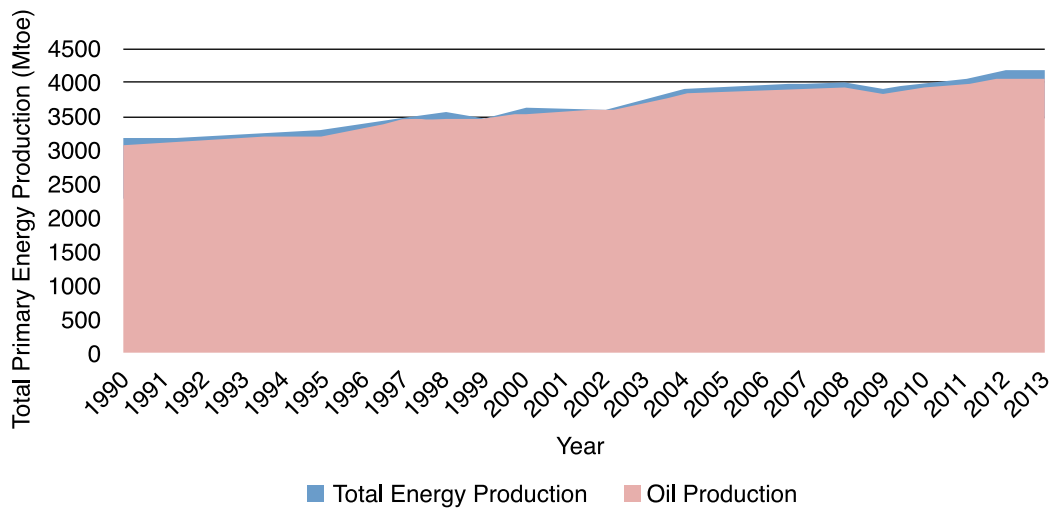


Figure 1.5 Global total primary energy production

Figure 1.5 depicts the total energy production around the globe from 1990 to 2013. From the figure, it is evident that oil production is still the primary source for energy production as it accounts more than 90% of the total energy production with an annual growth rate of 1.1 % over the past decade (from 2000 to 2013). Oil products alone continue to dictate matters in terms of final energy demand, in which more than 60% of the global oil consumption are utilised by the transport sector and 96 % of oil derivatives have become the primary source of energy for transportation (GTS 2050). This phenomenon in turn, suggests the increase in carbon emissions has other detrimental effects on the environment.

1.1.2 Energy Usage - Current Status in Malaysia

The World Bank had reported a substantial economic growth rate for Malaysia over the last 20 years, recording an average value of 6% (The World Bank 2014). Intrinsically, this translates into an increase in vehicle ownership, as shown in Figure 1.6. The increase in the number of vehicle ownerships as well as their demand for travel, impedes to a certain extent the mitigating means in place to reduce the environmental impact of transport as a whole. According to the National Automotive Policy (NAP) 2014, the sales of passenger as well as commercial vehicles increased by 3.9 % in 2013 from 2012 and Malaysia was ranked 20th for vehicle sales globally in 2012. Among the ASEAN countries, Malaysia was ranked third after Thailand and Indonesia in terms of total vehicle sales (NAP 2014).

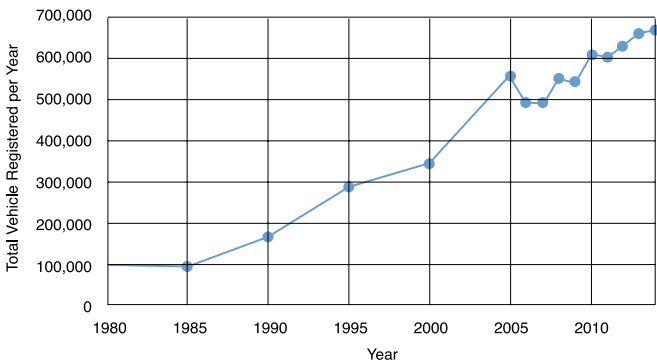


Figure 1.6 Total vehicles registered in Malaysia from 1980 to 2014

Source: http://www.maa.org.my/info_summary.htm

A further breakdown study on the modes of transportation reveals that road transport is still the dominant mode of transportation as it accounts for approximately 94.8% of passenger and 96.4 % of freight carried respectively, as depicted in Figure 1.7. It is worth mentioning that the average proportion of private and public transport vehicles for road transport from 1990 to 2008 were 97.22% and 2.78%, respectively. These figures indicate that there is a large disparity between the two modes, with the public transport share dwindling over the years, as it fell from 3.42 % in 1990 to 1.9 % in 2008 (Ong et al., 2012). The ineffectiveness of public transport is the main cause for this disparity. It is also apparent that water is the least used mode for passenger transportation whilst air travel, accounts 0.05 % for passengers and 0.1 % for cargo respectively.

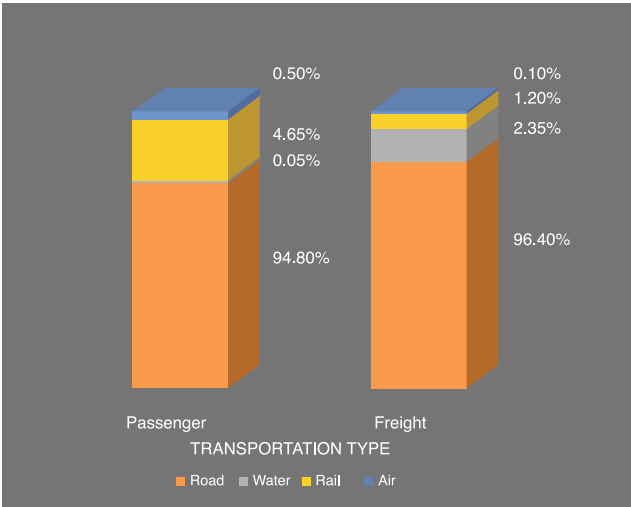


Figure 1.7 Variation of type of transportation with respect to transportation mode

Source: Ong et al. 2012

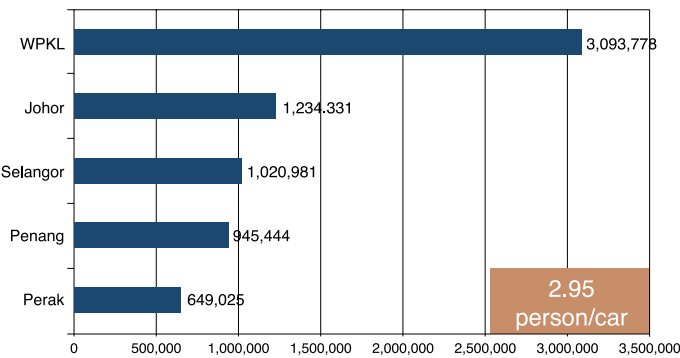


Figure 1.8 Five States in Malaysia with the Most Cars in 2011

Source: Shuhaili et al. 2013

The statistics in Figure 1.8 show the five states in Malaysia with the highest usage of fossil fueled vehicles for the year 2011 (Shuhaili et al, 2013). Kuala

Lumpur which is known as the heart of Malaysia, leads with the most usage of fossil fueled based vehicles, despite all the public transport that serves the city centre. It shows the ineffectiveness of public transport as people prefer to use their own cars while travelling to their destination. Besides, the stakeholder had pointed out that some roads were designed such that it took a longer route to reach their destination. The lack of proper planning and design make the traveller consume time although the destination is very near.

Currently, most of the cars in Malaysia are running on fossil fuel. In terms of electric vehicles, there are two major types of electric vehicles being currently

used in Malaysia i.e. the hybrid electric vehicle (HEV) and the full electric vehicle (FEV). The ownership of electric vehicles in Malaysia remains low, as these cars are more costly compared to conventional ICE cars. The influence of the cost factor on electric vehicle ownership is evident from the hike in electric vehicle sales during the tax rebate period. According to data by the Malaysian Automotive Association (MAA) (Tee, 2014), a total of 18,967 units of hybrids were sold in 2013, which was a 23.5% increase from the 15,355 units sold in 2012. (Mahalingam, 2014) reported a 11.7% fall in sales of hybrid vehicles in the first six months of 2014, after the removal of the tax rebate for completely-built-up (CBU) hybrid cars.



Figure 1.9 Existing Klang Valley Integrated Rail system

Source: SPAD 2014

Even though the railway system had been established ever since the colonial era, rail transportation in Malaysia has been sidelined in favor for road transportation. Currently, only the Klang Valley area is serviced by intra-city rail transport. The existing intra-city rail network is shown in Figure 1.9. To improve coverage and capacity, the government is currently expanding the intra-city rail transport by extending the LRT lines and building a new Mass Rapid Transit (MRT) system. In 2011 and 2012, more than 40 coaches had been built in Lembah Klang to ensure rail transportation is available and extensive enough to support all the rail transportation users at these residential areas (MOT, 2012). In terms of energy usage, some of the trains in Malaysia are still running on diesel (known as diesel multiple unit, DMU) and only some have been upgraded to electric trains (known as electric multiple unit, EMU). For intercity train, ETS (Electric Train Services) is a train service run by KTMB that currently operates between Kuala Lumpur and Ipoh. ETS is an EMU that runs on electricity and can travel up to 140km/hour. Besides ETS, Kereta Api Tanah Melayu (KTM) operates in

most parts of the country but it is still not accessible in some major cities such as Melaka, Kuantan, Kota Bharu etc. In the year 2011, the government has increased the capacities of coaches needed to support the number of passengers by 1.7 to 4 times higher than before in certain highly populated residential areas (The Prime Minister's Office of Malaysia, 2010)

For a maritime point of view, there is less emphasis from the government as compared to rail and road. However, maritime transport is still relevant within Sabah and Sarawak as the people use Sungai Rajang and Sungai Kinabatangan to commute from one area to another area (Britannica, 2014). The usage of maritime transportation will eventually pollute the ecosystem or marine biodiversity due to the spillage of oil. On top of that, maritime transportation still uses diesel to power up its engines and travel the seas. This can contribute to airborne emissions and Greenhouse Gases (GHG) from ships (IMO, 2015).

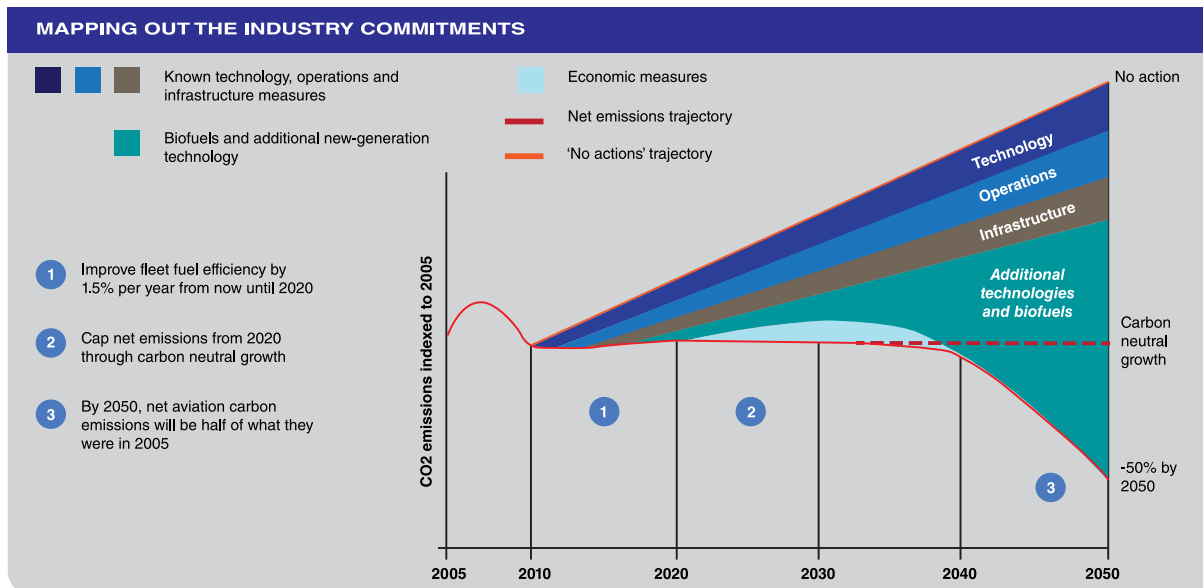


Figure 1.10 Carbon Neutral Growth by 2020 (MAS 2012)

Source: Carbon neutral growth by 2020 (CNG 2020) Chart, www.enviro.aero

As for airplanes, fossil fuel is used which emits a great amount of carbon that can pollute the air and increase the greenhouse effect. The International Air Transport Association (IATA) declared in 2009 that as an industry, Malaysia would achieve carbon neutral growth from 2020 and halve aviation carbon emissions by 2050. A 4 pillar strategy would be performed to accomplish continuous effectiveness namely using innovative technology, increase in efficiency

of operational implementation and improving the infrastructure of air traffic and airport management. Economic measures, the fourth pillar, would be used by 2020 to bridge the gap between these pillars and carbon neutral growth in order to reduce emissions (MAS, 2012). Table 1.1 summarises the overall current technology of transportation in Malaysia.

Table 1.1 Current Technology/Energy Usage According to Different Types of Transportation

Types of Transportation	Current Technology/Energy Usage
Road	• Conventional vehicles • Hybrid vehicles • Electric vehicles • Fuel cell vehicles
Rail	• Diesel/electricity fuelled rails
Maritime	• Diesel fuel
Aerospace	• Fossil fuel

1.1.3 Energy Efficiency

The concept of energy efficiency in general, is the ratio between input energy and output power. Traditionally, the energy efficiency of a particular vehicle is defined by the ratio of distance travelled per unit of fuel consumed which is often expressed as its fuel economy (miles per gallon (mpg), kilometres per litre (km/L)) or fuel consumption (litres per 100 kilometres (L/100 km)). This definition abides well with conventional internal combustion engines, nonetheless it poses a problem for electric based vehicles as there it is measured in terms of kiloWatt-hours per 100 miles

(kW-hrs/100 mi). Hitherto, there is no generalised definition of energy efficient vehicle/transportation that is able to cater for different types of power trains and fuels.



Environment

2.1 Global Outlook

Based on the discussions in Chapter 1, it is evident that transportation at present still relies heavily on fossil fuel as the primary source of energy. Resulting from this, there is a direct relation between the growth of the transportation sector and increased environmental pollution, particularly in the form of carbon dioxide (CO₂) and GHG emissions. Figure 2.1 shows the global CO₂ from transportation, where a steady increase can be observed. Based on the International Energy Agency's Energy Technology Perspectives 2014 (ETP 2014), the primary GHG which is CO₂, derived from transportation in general, accounted for 18% of global CO₂ emission. It is worth mentioning that CO₂ emitted from road transport is believed to be the main contributor of GHG which in effect, is the primary source of global warming.

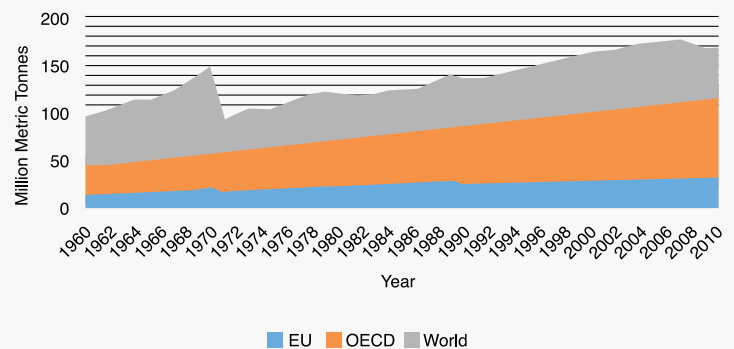


Figure 2.1 CO₂ emission from transportation

Source: ETP 2014

Apart from CO₂ and GHGs emissions, there are many other environmental issues associated with transportation. Table 2.1 lists down the primary environmental impact caused by failure of having a sustainable system throughout the full life-cycle of a mode of transport. Albeit the largest impact originates from the use of the transport itself, the effects of development and construction of infrastructure as well as vehicles, apart from the wastages upon

their disposal are other issues which add on to the environmental costs of transport.

The International Energy Agency’s Energy Technology Perspectives 2014 (ETP 2014), suggested three possible scenarios which illustrate the future by 2050. These scenarios need be explored in the event the world at large does or does not take heed of the imminent vulnerability of unsustainable energy utilisation.

Table 2.1 Main environmental problems from transport

Main Environmental Problems from Transport	
Resource Usage	• Large amounts of oil-based resources used for transport • Extraction of infrastructure construction material
Climate Change	• Emission of CO₂ and other global warming gases
Waste	• Vehicles, fluid, tires
Air Pollution	• Local emissions of Carbon Monoxide (CO), particulate matter (PM), lead, Volatile Organic Compounds (VOCs), hydrocarbons (HC) and NOx
Noise and vibration	• Quality of life for those living nearby roads, airports, stations, ports
Land take	• Land used for infrastructure • Habitat fragmentation
Water impact	• Pollution from spillage • Pollution from runoff • Changes to water systems by infrastructure

Source: Banister *et al.*, 2000

The following scenarios that were extracted from the BLUE Map scenario are as follows:

6 Degree Scenario (6DS) – In this scenario, the average global temperature rise in the long term is projected to be at least 6°C. This is an extension of the current trend, where the energy usage and total GHG

emissions increase by more than 60 %, as compared with 2011 by 2050. This scenario can transpire due to the absence of efforts to stabilise atmospheric concentrations of GHGs.

4 Degree Scenario (4DS) - The 4DS envisages the long-term global temperature rise to be capped at 4°C,

which requires significant additional cuts in emission for the period after 2050. Nonetheless this scenario still potentially brings forth drastic climate changes. It takes into consideration recent pledges made by countries to limit emission and step up efforts to improve energy efficiency. This enthusiastic scenario requires significant changes in terms of policy as well as adaptation of green technologies that are not asserted in the 6DS.

2 Degree Scenario (2DS) - The 2DS by 2050 is the most desirable scenario envisioned by the IEA. It describes an energy system that limits the average global temperature increase to 2°C. The 2DS identifies changes that are required to ensure a secure and affordable energy system in the distant future. It sets the target of reducing energy and process-related CO₂ emission by more than half in 2050, as compared to 2011. It also ensures that they would continue to decrease thenceforth. This scenario may be achieved provided that both energy and non-energy sectors plays their role in reducing CO₂ and GHG emissions.

All the aforementioned scenarios conform generally with the World Energy Outlook's (WEO) Current Policy Scenario through 2035. It is worth mentioning that the European Union (EU) as well as the World Business Council for Sustainable Development (WBCSD), have also outlined a plan or a comprehensive vision to reduce emission from transportation through various means. In order to achieve 2DS or shift the scenario from the current situation of a mere transportation angle, countries around the globe have begun to move towards exploiting other technologies, as well as enforcing policies that favour this ideal scenario.

2.2 Environmental Impact of Transportation in Malaysia

Transport systems have had a major impact on the status of the environment in Malaysia. As illustrated in Table 2.1, the impact of gaseous emission is related to climate change and air pollution, whilst health risks and nuisance are caused by the increase in noise levels. Apart from that, the infrastructure built especially for transport does have a significant impact on ecosystems and the landscape. Furthermore transport also has other effects on society such as by creating high congestion levels resulting in time loss. However, this chapter will focus on the first two types of impact caused by transport systems because they are the more severe ones.

2.2.1 Road

For Malaysia, the increasing trend of CO₂ emission from all modes of transportation is best illustrated in Figure 2.2, which shows a staggering increase of 184.9 % over the last two decades. Furthermore from Figure 2.3, it is also evident that Malaysia is ranked third in ASEAN after Indonesia and Philippines in terms of the amount of CO₂ contributed from the transportation sector over the past decade.

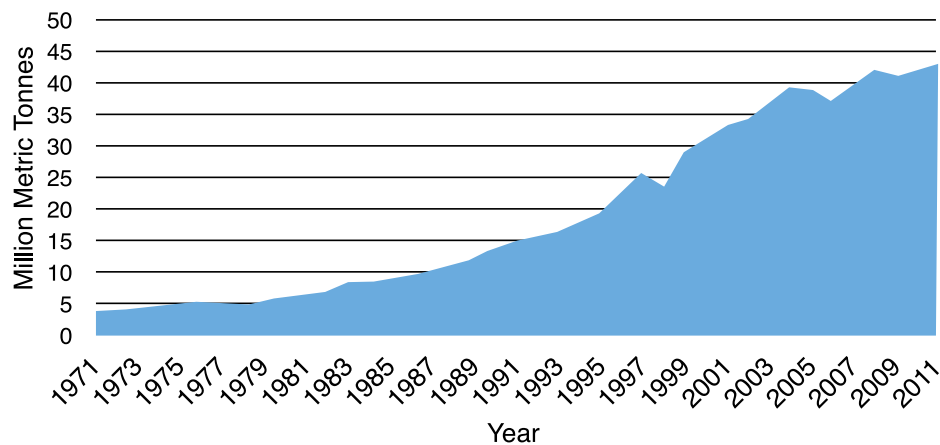
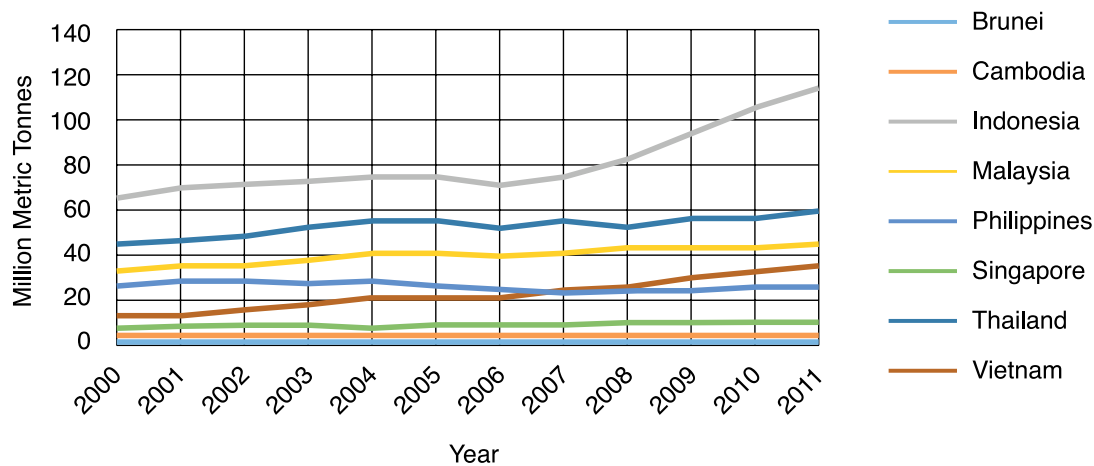


Figure 2.2 Malaysia's Carbon Dioxide (CO₂) emission from transportation

Source: IEA 2014



*Data unavailable for Lao PDR and Myanmar.

Figure 2.3 CO₂ emission from transportation amongst ASEAN countries

Source: IEA 2014

Ong et al. performed a study by utilising a common road transport emission model within the European environment, namely the Computer Programme to estimate Emission from Road Traffic (COPERT 4), to compute the emission of road transport in Malaysia (Ong et al., 2011). It was established from this study that passenger cars were the main source of GHG pollutants, whilst motorcycles were found to be the major contributor of methane (CH_4) emission.

Amongst other findings, passenger cars as well as motorcycles were the main causes of CO_2 and VOC emission, whilst light and heavy duty vehicles which run on diesel engine were the main contributors of PM exhaust emission. The study concluded that road transportation particularly private passenger vehicles, contributes the highest amount of CO_2 followed by NO_x towards the GHGs as illustrated in Figure 2.4.

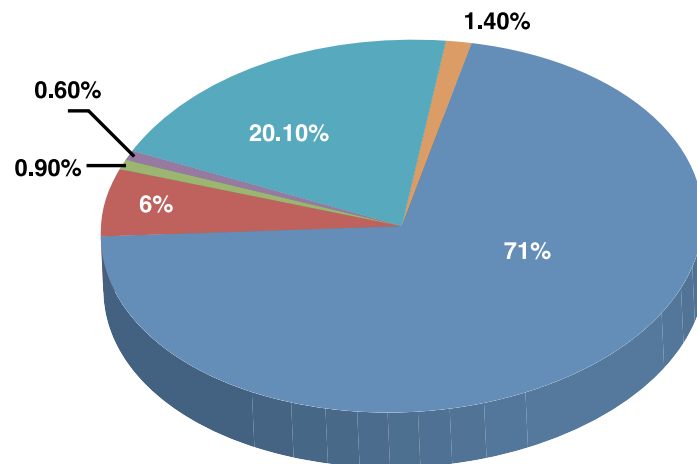


Figure 2.4 CO_2 equivalent emissions for road transport in Malaysia

Source: Ong et al., 2011

Through the development of the variety of transportation modes all over the world, it is undeniable that every individual's mobility has risen up to a very convenient level. However, the evaluation of scientific research proclaims that transport systems have become a major public concern because of

their negative impact on the environment which can be directly observed via subsequent studies. Land transportation is currently the primary source of the extremely worrying state of the pollution that is affecting the environment. As traffic levels are predicted to increase in the future, road transport

which is the main user of petroleum will continue to be a significant contributor to GHG emissions (Oh & Chua, 2010). Fine particulate matter resulting from air pollution effects human health especially for people who suffer from respiration diseases. It also gives rise to the increasing health cost. Densely populated areas are significantly affected by these air pollutants compared to the effects of pollutants produced in isolated areas. Meanwhile, the noise impact due to traffic has differing adverse effects such as annoyance

and increased blood pressure (Den Boer & Schroten, 2007). In addition, noise also can be very distressing, affect sleep patterns especially for children and consequently affect people's quality of life.

2.2.2 Rail

Rail transport depends both on diesel and electricity. In terms of performance, electric trains generally emit less CO₂ emission than diesel trains.

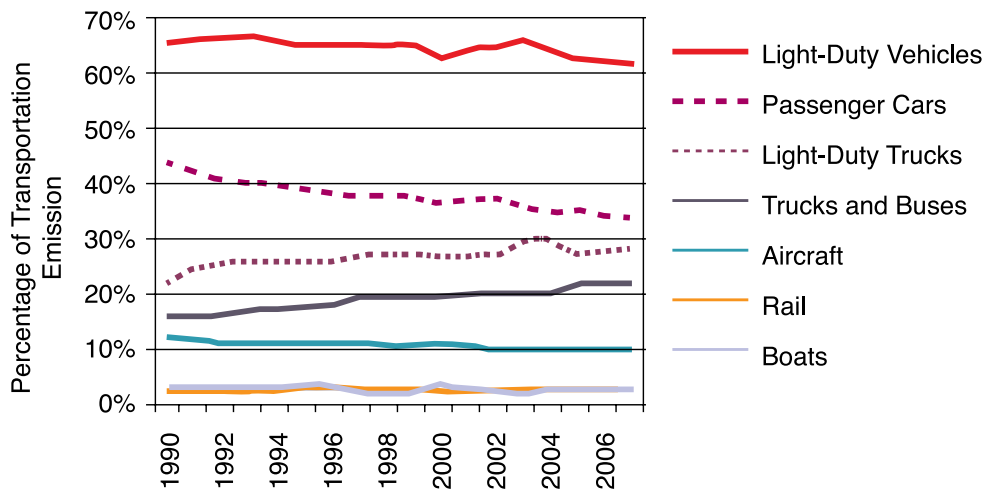


Figure 2.5 CO₂ emission from transportation sector by mode

Source: EIA 2009

Figure 2.5 shows the emission trends for different modes of transport (EIA, 2009). From the figure, it can be seen that CO₂ emission of rail transport is lower than the emission produced by road transport. In addition, people who live close to transport infrastructure worry over the noise levels (Transit, 2011). In long term, it will have an impact on their health.

2.2.3 Maritime

Table 2.2 shows the countries with the world's worst environmental conditions according to the proportional composite environmental (pENV) rank. It highlights the rankings for population density (PD), population growth rate (PGR), governance quality (GOV), Gross National Income (GNI), natural forest loss (NFL), natural habitat conversion (HBC), marine captures

(MC), fertilizer use (FER), water pollution (WTP), proportion of threatened species (PTHR), and carbon emissions (CO₂). Constituent variables used to create the pENV were NFL, HBC, MC, FER WTP, PTHR and CO₂ ranking (Bradshaw et al, 2010).

Overall, Malaysia was ranked as the 8th world's worst environment. Countries can perform poorly for many differing reasons. Malaysia had a high relative

CO₂ emission level and was ranked at 11 in the CO₂ category and at rank 77 for water pollution. This demonstrates that environmental impact in one aspect is partially mirrored by the impact in other measures presumably because high urbanisation leads greater release of CO₂ through burning of fossil fuels and an ensuing higher proportion of species threatened with extinction owing to habitat loss and water pollution.

Table 2.2 Comparison of High Pollution Level Rankings among Countries (Bradshaw et al. 2010)

Rank	Country	Code	PD	GR	GOV	GNI	NFL	HBC	MC	FER	WTP	PTHR	CO ₂	pENV
1	Singapore	SGP	1	51	13	115	128	5	91	1	4	63	1	10.6
2	Rep Korea	KOR	14	158	56	154	23	61	20	17	21	29	5	20.4
3	Qatar	QAT	108	8	67	-	-	198	112	20	3	-	7	24.8
4	Kuwait	KWT	61	110	74	109	128	197	114	11	1	-	8	25.1
5	Japan	JPN	23	188	30	165	87	89	18	21	29	13	6	25.2
6	Thailand	THA	71	145	90	148	43	8	7	67	-	37	46	25.5
7	Bahrain	BHR	6	41	73	52	-	193	59	4	-	123	2	25.7
8	Malaysia	MYS	102	60	71	131	47	75	22	8	77	15	11	25.9
9	Philippines	PHL	36	70	122	144	22	20	48	57	70	3	38	26.7
10	Netherlands	NLD	16	166	8	151	171	25	11	12	-	173	4	27.0
11	Denmark	DNK	70	181	2	125	178	4	12	52	9	180	16	27.4
12	Sri Lanka	LKA	34	156	110	111	21	56	33	30	41	7	34	28.9
13	Indonesia	IDN	71	118	153	153	5	76	62	59	79	12	14	29.3
14	Israel	ISR	33	40	64	123	128	110	93	5	6	62	9	30.0
15	Bangladesh	BGD	5	80	166	134	84	1	26	45	81	36	101	31.2
16	Malta	MLT	4	154	21	36	-	214	127	69	2	138	3	34.0
17	China	CHN	64	149	129	166	194	111	3	29	33	20	47	34.5
18	New Zealand	NZL	177	128	6	113	98	89	73	13	91	1	93	35.4
19	Iceland	ISL	207	144	2	44	128	195	13	2	106	-	-	36.9
20	Honduras	HND	124	66	135	76	1	39	125	82	72	44	75	37.0

Based on the report done by International Transport Forum, Paris December 2014; the ports with the largest absolute emission levels due to shipping were Singapore, Hong Kong (China), Tianjin (China) and Port Klang (Malaysia). Table 2.3 shows the ports with the largest percentage emission levels related to CO₂ and Sox, with Malaysia at 4th and 3rd rankings respectively.

International shipping was estimated to have contributed about 2.7% to the global emission of CO₂ in 2012. Table 2.5 illustrates the overview of studies on global shipping emissions comprising of CO₂, SO_x, NO_x and PM. Meanwhile, Figure 2.6 shows that Asia contributed the most to global shipping emissions in year 2011. As acknowledged by the Kyoto Protocol with regard to the climate change challenge, IMO aims to reduce the GHG emission from ships.

Table 2.3 Ports with the Largest Percentage Emission levels (Merk, 2014)

Top 10 ports (CO ₂) emissions	Share of total	Top 10 ports (SO _x) emissions	Share of total
1. Singapore	5.9%	1. Singapore	6.5%
2. Hong Kong	2.2%	2. Hong Kong	2.3%
3. Rotterdam	2.0%	3. Port Klang	2.2%
4. Port Klang	1.9%	4. Tianjin	2.1%
5. Tianjin	1.8%	5. Shanghai	2.0%
6. Shanghai	1.7%	6. Fujairah	2.0%
7. Fujairah	1.7%	7. Busan	1.7%
8. Busan	1.4%	8. Kaohsiung	1.6%
9. Kaohsiung	1.4%	9. Ulsan	1.0%
10. Antwerp	1.2%	10. Belium	0.9%
Total Top 10	19.0%	Total Top 10	22.3%

Table 2.4 Ports with the Lowest Relative Emissions (Merk, 2014)

Port with lowest CO ₂ emissions per ship call	Country	Port with lowest SO _x emissions per ship call	Country
1. Kitakyushu	Japan	1. Kyllini	Greece
2. Imabari	Japan	2. Guernsey	United Kingdom
3. Kyllini	Greece	3. Sundsvall	Sweden
4. Guernsey	United Kingdom	4. Troon	United Kingdom
5. Annapolis	USA	5. Trelleborg	Sweden
6. Grand Cayman	Cayman Islands	6. Heysham	United Kingdom
7. Sundsvall	Sweden	7. Marstal	Denmark
8. Troon	United Kingdom	8. Jersey	United Kingdom
9. Trelleborg	Sweden	9. Gourrock	United Kingdom
10. Heysham	United Kingdom	10. Naxos	Greece

Source: Author's calculations and elaborations, based on data from Lloyd Marine Intelligence Unit

Table 2.5 Overview of Studies on Global Shipping Emissions (Merk, 2014)

	Estimation (mln tonnes)	Year	Share of total emissions	Source
CO ₂	949	2012	2.7	IMO 2014
	1050	2007	3.3	IMO 2009
	944	2007	-	Psaraftis & Kontovas 2009
	695	2006	-	Paxian <i>et al.</i> 2010
	813	2001	3	Eyring <i>et al.</i> 2005
	912	2001	3	Corbett & Koehler 2003
	501	2000	2	Endresen <i>et al.</i> 2003
	419	1996	1.5	IMO 2000
SO _x	10	2012	-	IMO 2014
	15	2007	-	IMO 2009
	14	2005	10	ICCT 2007
	12	2001	9	Eyring <i>et al.</i> 2005
	13	2001	9	Corbett & Koehler 2003
	6.8	2000	5	Endresen <i>et al.</i> 2003
	16.5	2005	-	Cofala <i>et al.</i> 2007
NO _x	17	2012	-	IMO 2014
	25	2007	-	IMO 2009
	22	2005	27	ICCT 2007
	24.3		-	Cofala <i>et al.</i> 2007
	21.4	2001	29	Eyring <i>et al.</i> 2005
	22.6	2001	31	Corbett & Koehler 2003
	12	2000	17	Endresen <i>et al.</i> 2003
PM ₁₀	1.3	2012	-	IMO 2014
	1.8	2007	-	IMO 2009
	1.9		-	Cofala <i>et al.</i> 2007
	1.7	2001	-	Eyring <i>et al.</i> 2005
	1.6	2001	-	Corbett & Koehler 2003
	0.9	2000	-	Endresen <i>et al.</i> 2003

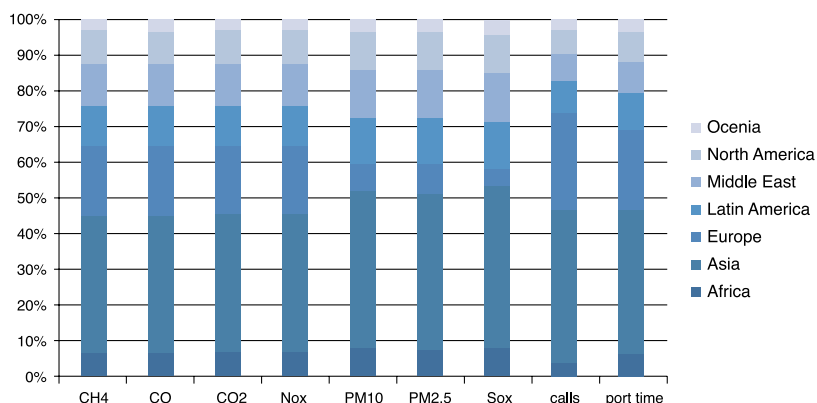


Figure 2.6 Shipping Emission, Port Calls and Port Time per Continent for the year 2011 (Merk, 2014)

Source: Author's calculations and elaborations, based on data from Lloyd Marine Intelligence Unit

2.2.4 Aviation

The environmental impact of aviation contributes to climate change as aircraft engines release noise, heat, gases and particulates. Other emissions may include nitric oxide and nitrogen dioxide (together termed oxides of nitrogen or NOx), water vapour and particulates (soot and sulfate particles), sulfur oxides, carbon monoxide (which bonds with oxygen to become CO₂ immediately upon release), incompletely burned hydrocarbons, tetraethyl lead (piston aircraft only), and radicals such as hydroxyl, depending on the type of aircraft in use (European Commission, 2005).

Emissions of NOx are mostly effective in forming ozone (O₃) in the upper troposphere as large jet airliners flown at the high altitudes around the troposphere. A greater global warming effect would occur when high altitude (8-13km) NOx emissions result in greater concentrations of O₃ than surface NOx emissions (European Commission, 2005). Based

on Figure 2.6, the NOx emission was recorded at 20.10%, the second largest emission contribution after CO₂.

The aircraft's sulfur and water emissions in the stratosphere tend to deplete O₃, partially offsetting the NOx-induced O₃ increases. This problem does not apply to aircraft that fly lower in the troposphere, such as light aircraft or many of the commuter aircraft (European Commission, 2005). Besides that, the least significant vector is the release of soot and sulfate particles. Soot absorbs heat and has a warming effect while sulfate particles reflect radiation and have a small cooling effect. In addition, they can influence the formation and properties of clouds (European Commission, 2005). All aircraft powered by combustion will release a small amount of soot.

Year	2010	2011	2012
Group Total Emissions ('000 tonnes CO₂)	5,902.20	6,027.14	5,461.64

Figure 2.7 MAS Group Carbon Footprint (MAS, 2012)

Figure 2.7 shows that the MAS Group carbon footprint amounted to 5.46 million tonnes of CO₂ in the year 2012. This included fuel burn for the Group's aircraft and ground energy consumption (electricity, diesel and petrol) at all of the Group's Malaysian hubs - KLIA, Subang, Penang, Kuching, Miri and Kota

Kinabalu. Collectively, the aviation sector represents just 2% of global CO₂ emission (MAS, 2012). Based on Figure 2.8, jet fuel is by far the largest contributor to MAS carbon footprint at 98.36%. Aviation transportation contributes to high carbon footprint which slowly affects the surrounding environment.

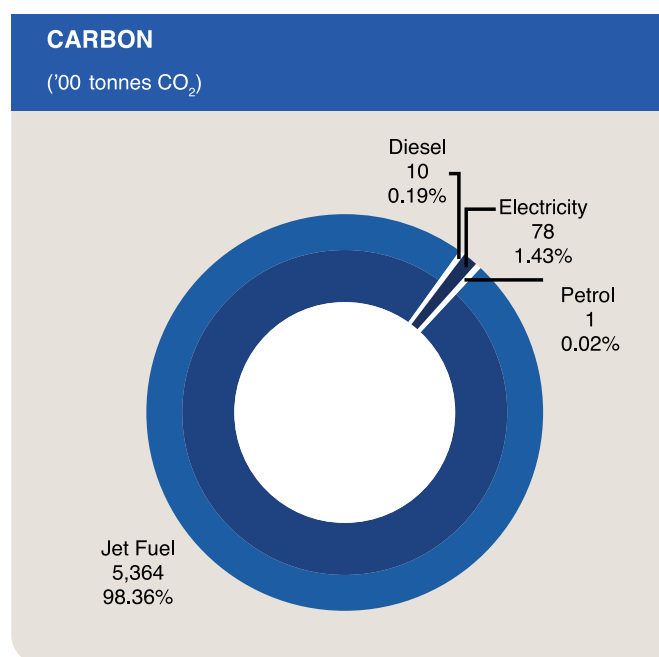


Figure 2.8 Percentage of Carbon Footprint by MAS (MAS, 2012)

Above these issues, the noise footprint contributed by aircraft is perceived as the most important environmental problem for people living close to

airports. Excessive noise is a major concern when aircraft operate out of airports situated in densely populated areas. However if compared with the

original commercial jets, aircraft nowadays are up to 30 decibels quieter which represents a 90% reduction in the noise footprint (MAS, 2012).

2.3 Effect of Energy Usage and Efficiency in Transportation on the Environment

The environment and transport development are always associated with each other. Ignoring the connection between transport and the environment

leads to global greenhouse gas emissions as depicted in Figure 2.9. In order to achieve the 2 °C target which has been highlighted in the earlier part of this chapter, the global emissions need to be reduced by about 40% to 50% before 2050 (PBL Netherlands Environmental Assessment Agency, 2012). Obviously from Figure 2.9, it is hardly possible to achieve this target if the current air pollution levels around the world increase continuously year by year, particularly in developing countries like Malaysia, hence also resulting in serious health issues.

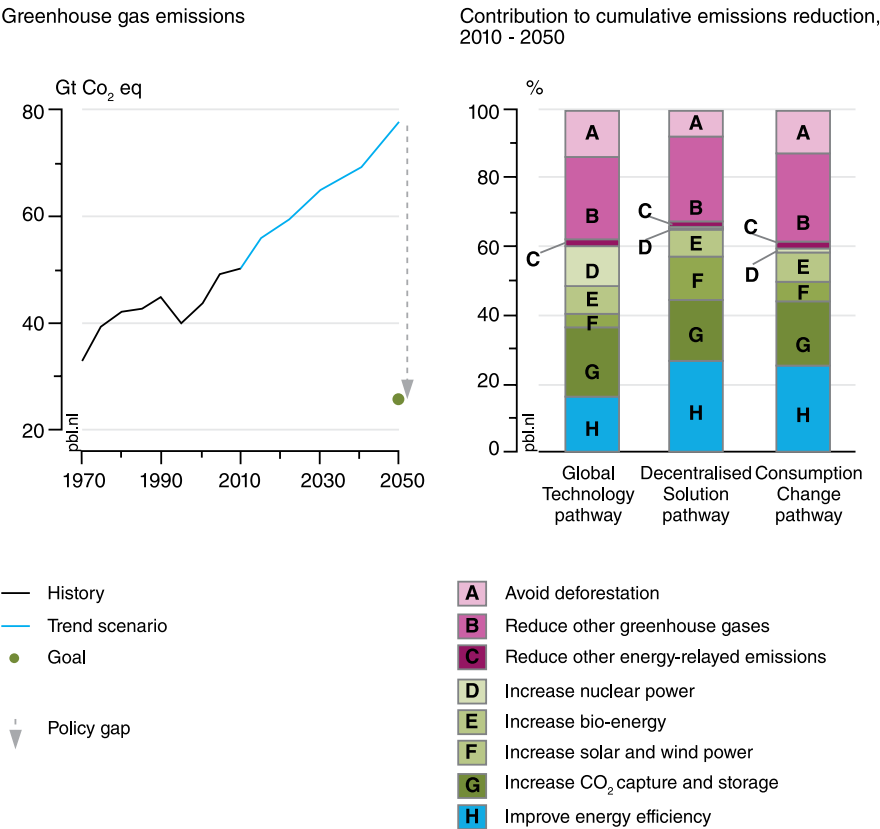


Figure 2.9 Different Mitigation Measures to Reduce Greenhouse Gas Emissions among Global Technology, Decentralised Solutions and Consumption Change pathway (PBL Netherlands Environmental Assessment Agency, 2012)

Source: PBL

Based on Figure 2.9, the trend scenario of greenhouse gas emissions is predicted to increase by another 60%, as such there is a large gap towards the aim to achieve 2 °C by 2050 (PBL Netherlands Environmental Assessment Agency, 2012). To reach the target, experts in energy usage and efficiency improvements in transportation need to boost their efforts at double the historical rate. The air pollution levels as mentioned in PBL Netherlands Environmental Assessment Agency Report 2012 are expected to increase in most of the developing countries compared to high-income countries which would eventually lead to considerable cost. Considerable costs which have resulted from the climate change can be seen from the rises in sea level, higher risks of extreme weather events which result in increase of rainfall, repeated flooding and landslides. These will give effects to delays and cancellations, or even pose a risk to air travel, damage the roads and rail lines. Apart from

that, air pollution would lead to costs in terms of health damage.

The outcomes of several studies show the significant costings involved in estimating the external social costs associated with transportation. The main costs are those concerning air pollutants, noise and accidents. Users of transport have tended to utilise more of less energy-efficient modes of transport, such as road transport instead of trains and air instead of roads. Meanwhile, energy-use per passenger-km is considerably higher for passenger cars and air transport compared to buses and trains. This has led to the increase in CO₂ emission. Transporting goods by rail and by sea is, on average, more energy efficient than transporting goods by lorry or by air (Johansson, 1997) as shown in Table 2.6 below.

Table 2.6 Specific Energy Use and Emissions of HC, NO_x, for Different Modes of Transport in Sweden (Johansson, 1997)

<i>Passenger transport Short distance</i>	Energy use ^a kWh/passenger-kmg/ passenger-kmg	Hydrocarbons NO ₂	Nitrogen oxides
Passenger car (no catalyst)	0.91	3.6	1.7
Passenger car (catalyst)	0.87	0.3	0.3
Bus	0.22	0.09	0.9
Electric commuter train ^b	0.05-0.13	-	<0.01
<i>Passenger transport Long distance</i>	Energy use kWh/passenger-kmg/ passenger-kmg	Hydrocarbons NO ₂ /passenger-km	Nitrogen oxides
Passenger car (no catalyst)	0.33		0.96—
Passenger car (catalyst)	0.32		0.08
Bus	0.13		0.6
Electric train ^b 0.1-0.2	-		
Aeroplane	0.7-0.9		0.6-1.6
<i>Goods transport</i>	Energy use kWh/net toone-km	Hydrocarbons g/net tonne-km	Nitrogen oxides g NO ₂ /net tonne-km
Lorry	0.2-0.6	0.06-0.2	0.7-1.9——
Electric train ^b 0.06-0.1	-	0.003-0.005	
Sea transport	0.05	0.01	0.45
Aeroplane	1.5-8	0.2-11	1.5-9

Note: ^a Energy end use. For vehicles using petroleum fuels primary energy use will be 10-20% higher than the energy use. For electric vehicles using electricity from hydro, primary energy will be only slightly higher than energy end-use. For electric vehicles using electricity from condensing plants, primary energy use might, however, be 2-2.5 times larger than the energy end-use.

^b Emissions from the use of electric trains are based on the Swedish electricity production. For an electricity system to greater extent based on fuel combustion, the emissions of hydrocarbons and nitrogen oxides will be higher but still much lower than the emissions from other modes of transport.

Source: M. Lenner. "Energy consumption and exhaust emissions regarding different means and modes of transportation", Swedish Road and Traffic Research Institute, Linköping, Sweden (1993) In Swedish, English summary.

Therefore, proper energy usage and efficiency improvements in transportation play key roles towards reducing global emission. For instance, improvements could be achieved through electric or hydrogen vehicles using low and zero carbon technologies. Chapter 4 will discuss in detail on technology of transportation. Nevertheless, the important approach would be to enhance the regulatory and socio-economic environment for public transportation, this will be further explained in other following chapters.

2.4 Challenges

Malaysians are lacking in awareness on the importance of preserving the environment. Only limited effort in the form of campaigns and exhibitions are being made to raise the knowledge of Malaysians about using public transportation services. The government itself, especially the Ministry of Transportation needs to work on all its incentives and policies regarding the development of transportation. One of the main methods of getting Malaysian closer to public transport is by creating a campaign for a 'Green Environment' to raise awareness of reducing pollution by using public transport.

Recently, on December 26, 2014, Air Asia launched an East Coast Flood Relief Campaign in aid of relief and rehabilitation efforts in affected states in Malaysia (Bernama, 2014). The campaign provided free transportation for relief goods and aid workers to Kota Bharu and Terengganu as well mounted a fund-raising drive to collect donations for post-flood rehabilitation. This type of campaign not only benefits society but also gives a good image of the services of public transportation in Malaysia.

Another step in making our public transportation more convenient to its passengers is to strictly monitor all the public transportation companies and check their overall performances in giving 'first class' services to their passengers. For example, 'Jabatan Pengangkutan Jalan' (JPJ) or Lembaga Perlesenan Kenderaan Perdagangan (LPKP) could summon or pull back the company's license if the services they provided did not follow the outline and rules which had already been listed by the Ministry of Transportation.

In rural areas, the challenge is in providing connectivity to urban markets for rural produce and the ability to do it at an affordable price. In urban areas, the challenge is that there are competing modes of transport like personal vehicles, where public transport is not sustainable. In getting people to choose public transport over personal vehicles there should be stringent quality parameters that need to be met. These relate to convenience and reliability, which are not as stringent for rural-urban connectivity or even for connecting one rural area to another.

Vehicles which are using fuel based engines, are the main cause of environmental pollution due to the high emission of carbon in their exhaust smoke. Malaysia needs to find ways to develop more electrically powered vehicles since we are far lacking in electric-vehicle transportation compared to other modern countries which are using EV as their main transportation. This is probably due to the high cost of building EV infrastructure and limitation of technology that we have.

As for other forms of transportation such as rail, the main challenge is the limited capacity of passengers that they can carry. Some highly populated areas

such as Kuala Lumpur, Ipoh, Johor Baru and other city centres need to have more rail transportation built in to streamline the number of passengers that they can carry, passengers will then find it to be more convenient as it is available at all times. The energy consumption during off-peak hours should also be managed properly to reduce waste of energy usage. The lack of connectivity between modes of transport also cause Malaysians to travel with their own vehicles instead of using public transportation.

Some residents in rural places are totally at a disadvantage since they cannot afford more efficient technology. One of the main objectives of the Government Transformation Programme Areas - GTP (Office of The Prime Minister of Malaysia, 2010), which was introduced by Malaysia's current Prime Minister Dato' Seri Najib Tun Razak on 28th January 2010, was to improve urban public transportation in order to serve Malaysians with efficient services no matter where they live. The government should not overlook the usage of transportation in rural places as the residents there also have the right to have an equal amount of good services which are currently available only in the city parts of the states.

People who live in geographically remote areas such as in Sabah and Sarawak have much more difficulty as their land is covered with hills and rivers which make it harder to build roads, railway tracks or other pathways to use for transportation. Most people there are still using their traditional ways of transportation such as boats and bicycles to go through the rivers and hills in order to reach their destination. They need to risk their lives walking through the bridges and facing high river currents, especially the children who are attending

their schools every day. It is not only risky, but energy consuming and time wasting as well.

Some modern countries are currently developing biofuel to reduce the emission rate of carbon in air. However, research on biofuel is very costly and there is insufficient funding and expertise in this particular area. The Malaysian government needs to allocate increased funds in the national budget for biofuel research in efforts to safeguard the environment and achieve our 2020 Mission which is to create a healthy environment for society to live in.

Bold measures are required in order to facilitate efforts in achieving the 2DS with respect to the transport sector, for which the employment of efficient technology alone is insufficient. Appropriate policies are crucial in further accelerating technological deployment in tandem with other mitigating measures towards attaining the aforesaid goal within the projected period. Initially, a comprehensive policy plan should be formulated by taking into account the implications of existing specific policies on different modes of transportation. Both fiscal and non-fiscal policies that are in place around the globe will be briefly discussed.





Policy

3.1 Global Outlook

3.1.1 Fuel Economy and Green house Gases Standards

i) Light Duty Vehicles

The first fuel economy standard scheme introduced in the United States of America (U.S.) was the Corporate Average Fuel Economy (CAFE) programme in 1975. Under the programme, separate standards were designated for cars and light trucks that weighed up to 3600 kg, whereby these vehicles were required to meet a minimum fuel economy target based on miles per gallon (MPG). The current U.S. standards, the Reformed CAFE which was revised in 2010 and included GHG emission limits, set targets for 2016 of 34.1 mpg from 26.4 mpg in 2009 as well as a

reduction of 26% in GHG emission. The Environmental Protection Agency (EPA) along with National Highway Traffic and Safety Administration (NHTSA) jointly issued the new GHG emission and fuel economy standards to cover model years (MY) 2017 to 2025 in 2012. A reduction of 35% on the average light-duty vehicle GHG emission rate is expected from the MY 2016 level for MY 2025, whilst the average combined fuel economy of LDVs is expected to rise from MY 2016 level of 34.1 mpg to 49.6 mpg in 2025.

The state of California enacted legislation in 2002 that regulations to achieve the maximum feasible reduction of GHGs emitted by passenger vehicles and light-duty trucks to be adopted by January 2005. The California Air Resources Board (CARB) approved regulations to include four GHG air pollutants namely CO₂, methane (CH₄), nitrous oxide (N₂O), and hydro-fluorocarbons exiting from new Low Emission Vehicles

(LEV II), starting with the 2009 MY in 2004 rather than CO₂ alone. California henceforth amended its regulations in order to allow compatibility with the federal EPA standards for MY 2012-2016. The LEV II is expected to reduce 30% of the average g/mile of GHG emission from new California cars and light trucks in 2016 as compared to MY 2004 vehicles.

In 2007, Canada switched to a mandatory form of voluntary fuel economy standards, that is the Company Average Fuel Consumption (CAFC), which were coherent with the United States revised CAFE standards. The CAFC was replaced by Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations in 2010, which regulated the limit of greenhouse gas emission from passenger cars and light trucks for model years 2011 to 2016 by adopting a footprint-based structure. The Canadian government foresaw that the average GHG emission performance of the 2016 Canadian fleet of new cars and light trucks would match an average level of 153 g CO₂/km which represents an approximate 20% reduction compared to the new vehicle fleet that was sold in 2007. In 2012, the 2017-2025 regulations were amended according to USA standards which offered more stringent annual fleet average GHG emission standards.

The Mexican government proposed a set of standards to regulate CO₂ emission and fuel economy for new passenger vehicles in 2012 that was adopted in July 2013, as NOM-163: *NORMA Oficial Mexicana de Emisiones de bióxido de carbono (CO₂) provenientes del escape y su equivalencia en términos de rendimiento de combustible*. These standards regulated CO₂ emission in grams per kilometre, providing the equivalent regulatory metrics for fuel economy in km/l to all manufacturers that

sold new light-duty vehicles with gross vehicle weights (GVWs) up to 3,857 kg, with the exception of those manufacturers that sold less than a total of 500 vehicles per model year. An average fuel economy of 14.9 km/l is expected in 2016 through the implementation of this regulation.

Owing to the unsatisfactory progress in voluntary passenger vehicle CO₂ emission in Europe, the European Union (EU) adopted CO₂ emission regulations in 2009. The standard established a mandatory fleet-average CO₂ emission target of 130 g/km to be reached by 2015. The regulation also defined a long-term target of 95g CO₂/km to be reached by 2020. In 2013, the passenger car standards were set at 95 g/km of CO₂, phasing it in for 95 % of vehicles in 2020. Whilst for commercial light vehicles, the standard established a fleet-average CO₂ emission target of 175 g CO₂/km to be fully phased-in from 2016 and a long-term target of 135 g CO₂/km from 2020. In 2012, these targets were updated in COM (2012) 393. The end of the phase-in for the short-term target was delayed to 2017 instead of 2016. The long-term target was adjusted from 135 g CO₂/km to 147 g CO₂/km and in 2013, the light-commercial vehicle standard was set at 147 g/km of CO₂ for 2020. As of September 2014, the Euro 6 emission and fuel quality standards were in place for both diesel and petrol passenger cars and LDVs equal or less than 1305 kg, whilst those for LDVs weighing more than 1305 kg would be implemented by September 2015.

China is in Phase III of its fuel consumption standards which were initially adopted in 2004. In contrast with policies adopted in the USA, EU and Canada, the first two phases of the regulation required that individual vehicle models comply with

fuel consumption regulations prior to their market penetration. The standards regulated both domestic and imported light-duty passenger vehicles with a GVW below 3,500 kg. The initial Phase III standards indicated that the fleet average fuel consumption for new vehicles of approximately 7 l/100 km (equivalent to 167g CO₂/km) by 2015 might be achieved. However, in 2012 the expectation was reviewed and an expected fleet average target of 6.9 l/100 km by 2015 was announced. Phase IV is currently under development in which the expected target of 5.0 l/100 km by 2020 is proposed.

The Government of India finalised the country's first passenger vehicle fuel-efficiency standards in January 2014 that would take effect from April 2016. The standards are expected to regulate new cars with the equivalent emission of 130g CO₂/km in 2016 and 113g CO₂/km in 2021. It is expected that with the implementation of these standards, 50 million tons of CO₂ would be kept out of the atmosphere in 2030 alone.

In Japan, the standards of LDVs are based on the "best in class" technology and are a function of vehicle weight. The Top Runner programme for passenger vehicles identifies the most fuel efficient vehicle according to the above mentioned criteria. There are currently two sets of targets, namely the 2010 standards and the new 2015 standards. According to government estimates, the 2010 targets are met once the average fuel economy for the entire vehicle fleet for passenger cars reaches 15.1 km/l (153.8 g CO₂/km) whilst for light trucks it is 16.3 km/l (124.4 g CO₂/km). The 2015 fuel efficiency regulations were introduced for small buses, and the applicability of standards for light trucks (cargo vehicles) was extended up to GVW

≤ 3.5 t as for passenger cars. The 2015 targets are met, if the fleet average fuel economy for passenger cars, light trucks and small buses reach 16.8 km/l, 15.2 km/l and 8.9 km/l, respectively.

The Average Fuel Economy (AFE) program was announced in 2005 and it was the first mandatory fuel economy standard employed by South Korea. The program set fuel economy targets of 12.4 km/l and 9.6 km/l for vehicles with an engine displacement of 1500cc or less, and for vehicles with an engine displacement of over 1500cc, respectively. Industry players were required to abide by the targets by 2006 for domestic vehicles and 2009 for imported vehicles. South Korea announced the Five-Year Plan for Green Growth in 2009, which required that 100 % of the country's automobiles meet a fuel economy/GHG emission target of 17 km/l or 140g CO₂/km equivalents by model year 2015. The legislation was phased in over a four year period from 2012 to 2015.

ii) Heavy-Duty Vehicles

Japan initiated the first fuel economy standards for heavy-duty vehicles from around the globe in 2006. The standards were similar to that of LDVs in Japan that were based on gross vehicle weight and the best in class principle of the "Top Runner" programme. Fuel economy levels were mandated to improve 12% from 2002 to 2015.

The U.S. EPA initiated rulemaking procedures on GHG emission from heavy-duty vehicles in 2009 and the Obama administration has declared that a national policy on heavy-duty fuel efficiency and GHG emission must be formulated for vehicles beginning with MY

2014. It is expected that a reduction of 10% and 15% of CO₂ emission and fuel consumption of gasoline and diesel will be announced by MY 2018.

The state of California, on the other hand, adopted the measures for reducing GHGs and improving the fuel economy of HDVs in 2008 through regulating long-haul truckers to install fuel efficient tyres and aerodynamic devices on their trailers. As of January 2010, no 2011 or subsequent model year HD tractor, including sleeper-cab tractors pulling a 53-foot or longer box-type trailer would be allowed to operate on a highway within California, unless such a tractor was a U.S. EPA SmartWay Certified Tractor. Additionally, as of 1 January 2013, no 2010 or previous MY HD tractor pulling a 53-foot or longer box-type trailer can operate on a highway within California unless their vehicle tyres are of U.S. EPA SmartWay Verified Technologies.

China is the third country in the world after Japan and the U.S. to adopt fuel consumption standards for HDVs. The standards released in February 2014 are expected to reduce approximately 11 % of HDV fuel consumption, which would in turn, reduce between 5 to 6 million tonnes of annual oil consumption. The European Union is discussing methods and standards for CO₂ emission from HDVs, nonetheless there has been no legislation to date.

iii) Rail

The International Union of Railways (Union Internationale des Chemins de fer, UIC) is responsible for regulating emission standards amongst its global members for rail locomotives through the UIC 624 standards. The standards are applicable to new diesel

engines used in new locomotives or for powering of existing ones for railway traction, excepting traction engines with an output of less than 100 kW and other special locomotives such as refinery or mine locomotives. The current emission standard being employed is the UIC 624 -4, which was enforced in 2012. The EU is currently employing the Stage IV, Directive 2004/26/EC emission reduction standards which are applicable to railcars and locomotives with diesel fuel engines of power greater than 130 kW. As of 2012, the USA EPA had introduced Tier 3, a more stringent emission requirements for diesel locomotives of all types namely, line-haul, switch, and passenger rail. It is expected that by 2015, Tier 4 standards are in effect which require the availability of ultra-low-sulfur diesel fuel for exhaust gas after-treatment technologies.

iv) Maritime

According to the Second International Maritime Organisation (IMO) GHG Study 2009, international shipping was estimated to contribute approximately 2.7% of the global anthropogenic emission of CO₂ in 2007. As a result of the study, a regulatory framework on GHG emission was developed and two mandatory mechanisms with the aim of ensuring an energy efficiency standard for all ships were introduced. MARPOL Annex VI, Chapter 4 introduced the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP) in 2011. The EEDI is a performance-based mechanism that requires certain minimum energy efficiency in new ships over the employment of appropriate technologies for a specific ship design, whilst the SEEMP establishes a mechanism for operators to improve the energy

efficiency of existing ships. The regulations were entered into force as of 1st January 2013 and are applicable to all ships of and above 400 gross tonnages.

Apart from the international regulations already in place, several countries have taken the initiative to regulate emission domestically. Canada has its own domestic policy on regulating emission from marine propulsion engines. At present, compression ignition marine engines of less than 37 kW from the 2006 and later model years are regulated by the Off-Road Compression-Ignition Engine Emission Regulations. The Air Pollution Regulations of the Canada Shipping Act of 2001 administer black smoke density from ships in Canadian waters and within 1 mile of land. The emission standards and test procedures for engines are in conformance with those of the USA EPA.

As of 2004, the EU regulates conventional pollutant emission limits for inland waterway vessel diesel fuelled engines from 19 kW to 560kW under Stage III A of Directive 2004/26/EC. They also regulate sulphur limits for marine fuel used by ships and vessels operating in the sulphur emission control areas (SECAs) to 1.5%. The USA also regulates that the conventional pollutant emission limits comply with the IMO MARPOL Annex VI. The EPA administers the emission based on the engine capacity of the ships, Category 1 and Category 2 are typically marine diesel engines ranging in size from about 500 to 8,000 kW whilst Category 3 marine diesel engines range from 2,500 to 70,000 kW.

v) Aviation

In order to address emission growth and fuel efficiency for commercial aircraft, two initiatives are at present in effect, namely the EU ETS and the International Civil Aviation Organization (ICAO) CO₂ certification requirement. The EU ETS began to mitigate emission growth from in-service aircraft by the incorporation of aviation into its own regional cap and trade system for CO₂ in 2012. Nonetheless, this initiative met with resistance from some nations. In light of the effort taken by the EU ETS, the ICAO worked on its own global framework that employs the cap and trade system or offsets the mechanism model. In October 2013, a CO₂ certification requirement to serve as the basis for a global CO₂ standard for new aircraft including metrics, fuel efficiency test points and detailed certification procedures, was finalised by the ICAO's Committee on Aviation Environmental Protection (CAEP). The ICAO members aimed at achieving improved efficiency of 2% until 2020 with employment of the aforementioned certification.

3.1.2 Labelling

Consumer awareness may be cultivated by providing information on fuel economy and CO₂ emission through labelling. Directive 1999/94/EC requires all EU countries to display a fuel efficiency/CO₂ label on new cars. The label must include fuel consumption (l/100 km) and specify emission of CO₂ (g/km) for that particular model. The USA has been providing information on fuel economy for more than 30 years. In 2010, DOT and EPA jointly proposed new label designs for a range of vehicle technologies including

electric vehicles and plug-in hybrid electric vehicles, as well as for conventional gasoline and diesel vehicles.

The Australian government regulated fuel consumption labelling in 2004 for new vehicles that weighed up to 3.5 tonnes. As of 2009, the labelling scheme was amended to also include urban and non-urban test fuel consumption, as well as a combined

result apart from CO₂ emission. The Singaporean government in 2012 launched the Fuel Economy Labelling Scheme (FELS), in preparation for the Carbon Emission-based Vehicle (CEV) scheme. The label highlights the model's carbon emission per kilometre (CO₂/km), fuel consumption as well as the relative carbon emission performance.

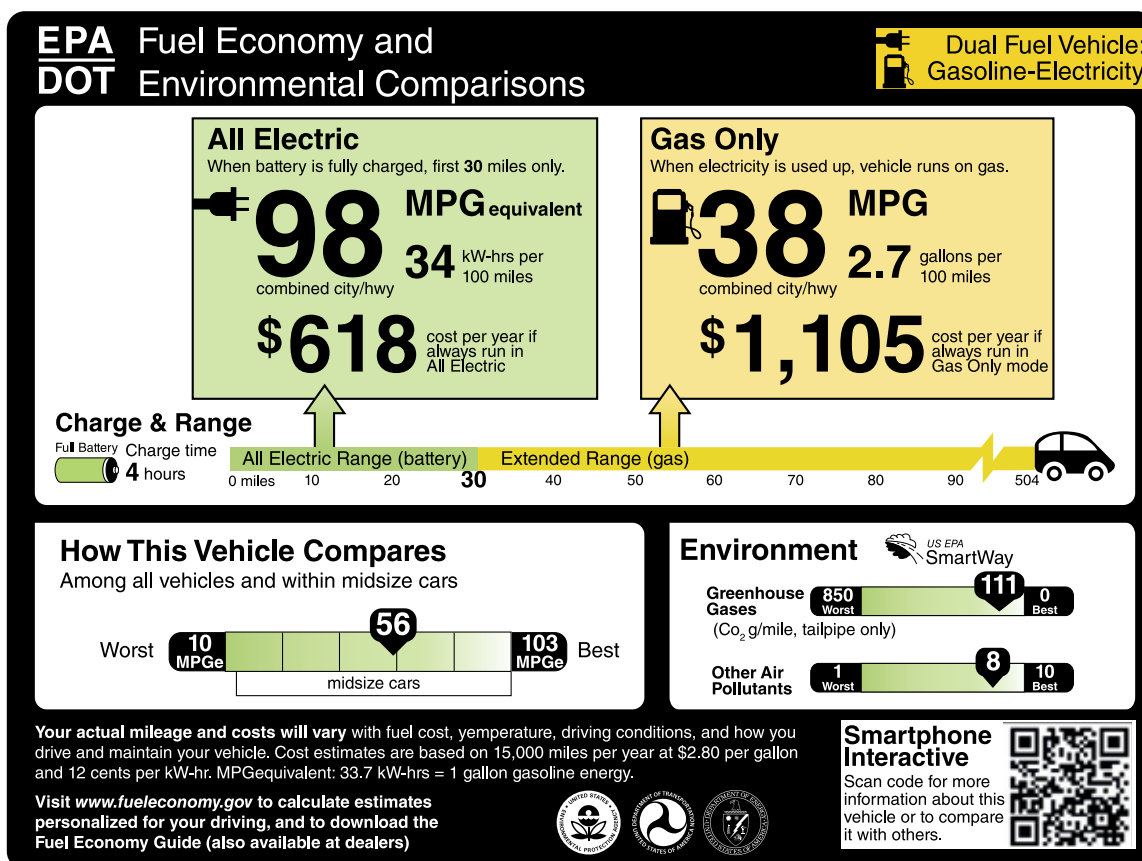


Figure 3.1 FELS USA

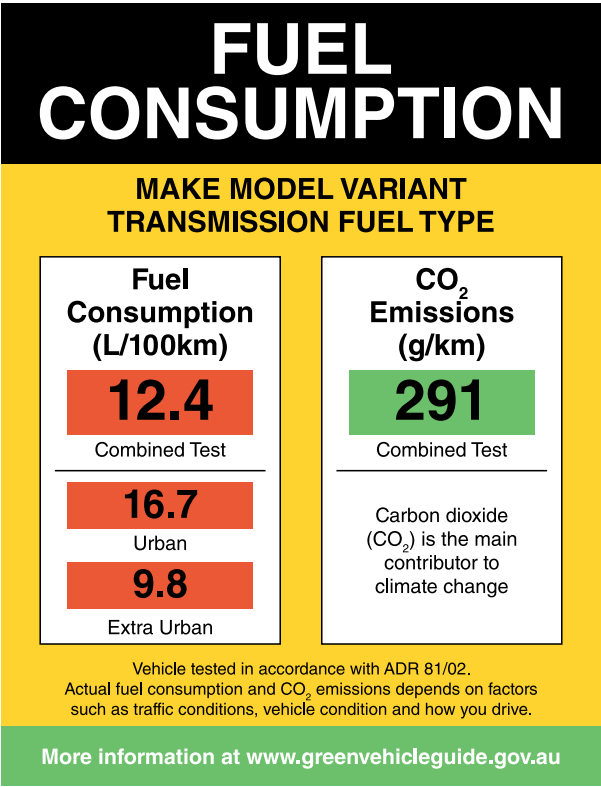


Figure 3.2 FELS Australia

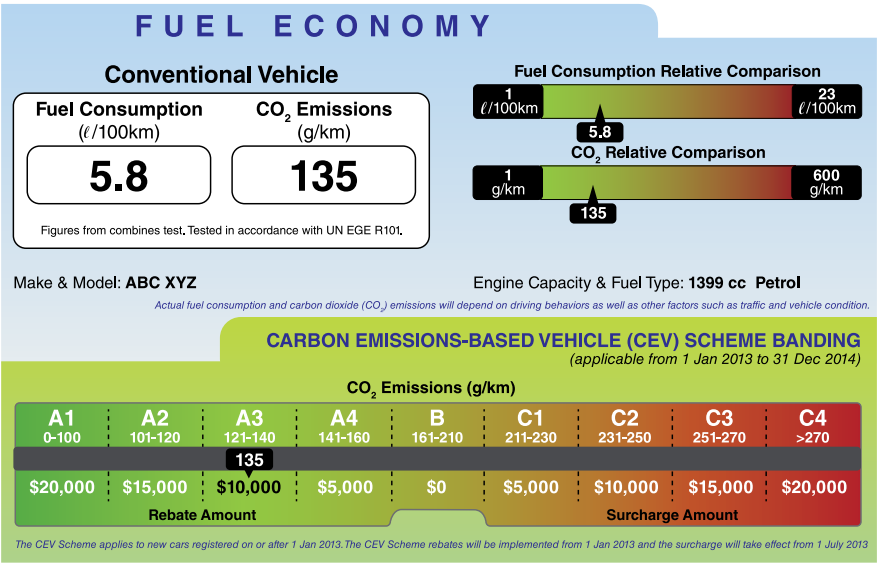


Figure 3.3 FELS Singapore

3.1.3 Renewable Fuel Policies

Biofuels are thought to be the key to break oil dependency, owing to the low or zero carbon source of energy for transportation. Therefore, the development of biofuels around the globe are sustained by a range of policies which include blending mandates; tax incentives or penalties; preferential government purchasing; government funded research, development, and deployment; as well as local business incentives for biofuel companies.

The EU sanctioned 10% of biofuel in the overall fuel mix by 2020 to facilitate the shift from oil reliance. The implication of tax breaks could be best illustrated when Germany introduced this policy in 2005. The production of biodiesel had increased to 520,000 tonnes, however this volume was significantly reduced to approximately 200,000 tonnes after introduction of a tax rate in 2009. The Renewable Fuel Standard 2 programme in the USA, is expected to increase the volume of renewable fuel required to be blended into transportation fuel from 9 billion gallons in 2008 to 36 billion gallons, by four fold in 2022 (EPA 2010a). The RFS2 sets certain quota for cellulosic and other advanced biofuels, as well as biodiesel. This programme also regulates different categories of biofuel to exceed explicit GHG emission threshold reduction values (EPA 2010b).

Nonetheless, an essential concern regarding conventional biofuel is the inherent food insecurity issue. The Chinese government forbids new biofuel projects that use grain or other human foodstuff in order to mitigate the aforementioned problem. Hence, the government supports cassava bioethanol and the

development of cellulosic bioethanol technologies (ICET 2008). Second and third generation biofuel are expected to have low life-cycle emission, however these advanced types of biofuel are not currently economically viable. Commercial-scale plants that were recently opened in Italy as well as in the USA, Brazil and Europe are expected to come online in the near future, somewhat suggesting substantial progress in technology development.

3.1.4 Low Carbon Fuel Standards

A low carbon fuel standard (LCFS) mandates a specific overall decrease in the average carbon intensity of all fuel. The state of California mandates an emission reduction of 10% from the entire fuel mix by 2020 from 2010. Eleven U.S. states in the Northeast and Mid-Atlantic Regions including British Columbia as well as Ontario from Canada have signed letters of intent and partial legislation, to introduce LCFS in coordination with California. In the EU, the Fuel Quality Directive COM-2007-18 requires a 6% reduction in transportation fuel derived CO₂ from 2010 to 2020. An additional 2% reduction should be obtained through the introduction of electric cars and environmentally friendly capture and storage technologies, subject to additional regulation. A further 2% reduction is to be obtained through the purchase of credits under the Clean Development Mechanism.

3.1.5 Vehicle Taxes and Incentives

Financial enticements at the point of vehicle purchase such as vehicle taxes and rebates evaluated by fuel economy or CO₂ emission, often known as “feebates” or in French “bonus-malus” systems may complement other enforced standards. These incentives adjust the effective price of a car, encouraging purchasers to choose more efficient, lower CO₂ emitting models.

This system discourages consumers from purchasing larger, heavier vehicles that might incur additional costs with differing fuel economy standards. This policy also assists as well as motivates the auto industry to sell their most efficient products and encourages them to introduce more fuel-efficient models. These incentive systems are generally linked to vehicle fuel economy or CO₂ rating/labelling systems as deployed by the USA, EU and Singapore.

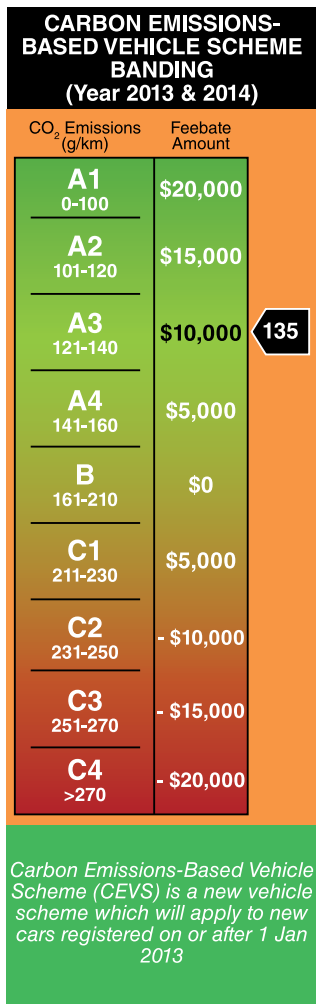


Figure 3.4 Singapore Vehicle Incentive Labelling

3.2 Current Status in Malaysia

Currently, there is no clear policy on energy usage and energy efficiency for transportation in Malaysia. As a matter of fact, the existing policies on transportation per se in Malaysia are somewhat scattered. The government has established the National Key Results Areas (NKRAs) under the Government Transformation Plan (GTP) in January 2010, to improve the socio-economic growth of Malaysia. One of the NKRAs initiatives is the improvement of urban public transport.

The Malaysia Land Public Transport Commission or Suruhanjaya Pengangkutan Awam Darat (SPAD) was given the mandate to manage policy planning and regulatory oversight on land transportation. SPAD is currently developing the National Land Public Transport Master Plan to establish the vision and direction for public transport in Malaysia. The first regional framework is being conducted for the Greater Kuala Lumpur (KL) / Klang Valley region as over 37% of the nation's GDP originates from KL and Selangor.

Amongst the initiatives under this plan are the implementation of Bus Rapid Transit (BRT) networks, Bus Expressway Transit (BET) services, dedicated bus lanes, Klang Valley Mass Rapid Transit (MRT) and the High Speed Rail (HSR) project. The MRT project alone is expected to significantly improve the coverage of rail-based public transport in the Klang Valley apart from increasing public transport utilisation by 33% in 2020. The Southern Corridor HSR that is expected to be operational by 2020 will connect 5 cities in Malaysia to Singapore.

Another policy that complements the Master Plan is the National Physical Plan 2 (NPP 2) which addresses the physical land usage in terms of transportation. Whilst the NPP2 promotes the use of rail as the main mode of transport, specific action plans are not detailed. The National Energy Policy addresses the issue of energy usage by the transportation sector in a macro perspective. Transportation related initiatives under the National Green Technology Policy 2009 include the development of infrastructure roadmaps and fleet test programs for electric vehicles and alternative fuels.

Although the National Biomass Strategy (NBS) 2020 that was unveiled in 2011 did not explicitly touch on its role in transportation, its national strategy on exploiting biomass for high value downstream activities included biofuels, which in turn suggests its vital role in green technology. This strategy has initiated Malaysia's first ligno-cellulosic bio-ethanol pilot plant in Tawau in June 2013 as well as South East Asia's first Commercial Scale 2nd Generation (2G) Bioethanol and Biochemical plant in the first phase of the Sarawak Biomass Hub invested by Brooke Renewables.

Nonetheless, a Working Group (WG) on Green Transportation and Climate Change has been recently established (first meeting in September 2014) at the national level under the purview of the Ministry of Transport. The WG's main thrusts include sustainable development of the national transport (land, air and maritime) sector, strategic issues and challenges, supporting legislation and policies, monitoring and evaluation, development of alternative energy and energy efficient use in the transportation sector with mechanisms required in the process. Details on the

roles and activities to be done by the WG are expected to stem from subsequent WG meetings.

Based on the Road Transportation Act 1987 (Akta Pengangkutan Jalan 1987), the Department of Transportation (JPJ) is in charge regarding vehicle license, checking and observing the technical issues of vehicles to ensure that the owners of vehicles place high consideration in getting their vehicles serviced and maintained in good condition (Road Transport Act 1987).

For the maritime sector, Malaysia is a member of the International Maritime Organization (IMO) and complies with the IMO regulations. Hence, new ships of 400GT and above built in Malaysia need to adhere to EEDI regulations and obtain the International Energy Efficiency Certificate (IEEC) before they can be put into service. Since 2013, new ships are required to implement SEEMP for improving energy management. Currently, the Malaysian maritime sector is looking into adaptation of the impending Market Based Measure (MBM) carbon pricing, which is part of IMO's efforts to reduce GHG emission from the maritime sector.

3.2.1 Fuel Quality and Emission Standards

Fuel quality in Malaysia is currently in compliance with the Euro 2M standards for both diesel and petrol, with an exception of Euro 5 diesel that is available at selected BHPetrol service stations in Johor. The introduction of Euro 5 diesel in Johor is essentially to accommodate diesel powered vehicles travelling to Singapore, as the Singaporean government has imposed tighter emission regulations as of mid-

2014. Nonetheless, the Energy Commission (EC) has approved the implementation of Euro 4M for Ron 97 by September 2015, Euro 4M for Ron 95 by October 2018, Euro 5 for diesel by 2020 and Euro 5 for petrol by 2025.

As for emission standards in Malaysia, there are two regulations in place, namely Environmental Quality (Control of Emission from Diesel Engines) Regulation 1996 and Environmental Quality (Control of Petrol and Diesel Engines) Regulation 2007. The enforcement of excessive smoke and emission from diesel vehicles is under the purview of the Department of Environment. Nonetheless, the present emission standards are not on par with international standards.

During the stakeholders workshop, attention had been raised regarding the impact of the Asean Framework Agreement (AFA) on transport emission standards. Under the ASEAN AFA on Facilitation of Goods in Transit and AFA on Facilitation of Interstate Transport, the vehicles involved should comply to emission standards as specified in Protocol 4 (Technical Requirement of Vehicle), where the exhaust emission is required to comply with 50% opacity (or Bosch Unit) or 50 HSU.

As for the aviation industry, Malaysia is committed to the strategic objectives of the International Civil Aviation Organization (ICAO) for reducing impact on the environment. In fact, Malaysia was the first in the world to implement the Continuous Descent Approach (CDA) at KLIA. CDA is fundamentally a flight procedure imposed on arriving aircraft at the airport in order to reduce fuel consumption, this in effect also reduces carbon emission apart from noise. Malaysia is currently formulating its own National Aviation Policy,

nonetheless the details of the policy have yet to be disclosed.

3.2.2 Renewable Fuel Policies

The palm based methyl ester blend biodiesel (B5) program, unveiled under the Malaysian Biofuel Policy 2005 replacing the palm olein blend “Envo Diesel”, was fully implemented nationwide in December 2014. Only six service stations in Putrajaya introduced the blend of 95% petroleum diesel and 5% palm oil biodiesel when the program began on June 2011.

Following the introduction of B5 biodiesel, the government is set to mandate the use of B7 biodiesel which increases the percentage of palm oil biodiesel in the blend to 7% in the first quarter of 2015. The government and the palm oil board are still in the midst of discussions with engine manufacturers and automobile associations to get warranties for B7. The existing B5 MS123:2005 standard is in accordance with the Euro 2M specifications. The government is currently studying the prospects of B10 and B20 biodiesel programs.

Concerns have been voiced during the stakeholder workshops on the use of biofuel as an alternative fuel source for transport. It was agreed that the use of biofuels would be beneficial provided that it does not impact food security and create environmental issues. Deforestation or the use of agricultural land to grow commodities for biofuel should be avoided. Instead, biofuel derived from agricultural or domestic waste should be given priority.

3.2.3 Vehicle Tax and Incentives

The Malaysian Automotive Association (MAA) revealed that there was an increase of 23.5% in the number of hybrid cars sold in 2013 as compared to 2012. The increase in sales were mainly due to the tax breaks given to both Completely Built Up (CBU) and Completely Knocked Down (CKD) hybrids and electric vehicles as announced in the 2011 Budget.

The National Automotive Policy 2014 (NAP 2014) aims to make Malaysia a regional automotive hub for energy-efficient vehicles (EEVs). The EEVs defined by the Malaysian Automotive Institute (MAI) include fuel efficient vehicles, hybrids, EVs as well as alternatively-fuelled vehicles, namely CNG, LPG, Biodiesel, Ethanol, Hydrogen and Fuel Cell. Only locally assembled or CKD hybrids and electric vehicle models are exempted from excise and import duties until 31st December 2015 and 31st December 2017 respectively.

Provisions of soft loans are provided for the development of infrastructure of EEVs including hybrids and EVs amounting to RM 130 million from 2014 till 2020. The policy also announces on lifting of the freeze on issuance of manufacturing licenses for EEVs apart from granting provisions of tax incentives under the Income Tax Act 1967. The Malaysian Green Technology Corporation (Greentech Malaysia) is expected to propose the Electric Mobility (eMobility) Blueprint in 2015. The blueprint will propose the same fiscal incentives that were offered for imported hybrid cars prior to its abolishment under the NAP 2014.

3.3 Challenges

The main challenge on the policy part of energy usage and energy efficiency for transportation lies in the fact that the governing power on the transportation sector is dispersed and distributed. There are far too many governmental agencies and authorities that decide on the policies relating to transportation in Malaysia, without a sole authority to be fully responsible and oversee the integration and cooperation of all parties. As a result, there are uncertainties on developing the action plans according to the policies, as well as difficulties in implementing and monitoring of the action plans.

In the NAP 2014, the government has made a clear indication of moving the automotive industry towards energy efficient vehicles, EEV. This will serve as a transition from conventional internal combustion engine based vehicles to eventually electric based vehicles. In this process, it is recognised that challenges will arise in terms of the infrastructure for supporting electric vehicles as well as the facilities to recycle the electrical vehicle, particularly batteries. In terms of energy usage, if the electric vehicles draw power from the conventional fossil fuel based generation plants, they are merely elsewhere-emission vehicles rather than zero-emission vehicles. Hence the infrastructure development for electrical vehicles should include development of renewable energy based power generation. Apart from that, the handling of waste from the electric vehicles and their related industries need to be planned out in advance. For instance, the recycling of batteries and the electric vehicles should be considered, akin to Hong Kong convention on ship recycling.

3.4 Recommendations/Action Plans

Based on stakeholder workshops, it can be concluded that there is an urgent need for an Integrated Transport Master Plan which is able to address the development of the transportation system in Malaysia in a holistic manner. This master plan must cover all land, water and air transport systems as a whole. For enhanced sustainable energy usage in the transport sector, the master plan should focus on the direction of the movement from private to public transport, primarily rail based transport. For this, transit-oriented development should be the main theme in urban development and need to be made an integral part of the master plan. The policy should also pave way for establishment of a Transport Research Centre and the further development of underutilised modes of transport, particularly water transport. In terms of freight, the use of rail for freight movement should be improved wherever possible. To ensure the success of this master plan, close collaboration between various responsible agencies and/or ministries is necessary.

In order to encourage people to move from private to public transport, both pull and push factors should be introduced. The pull factor may include free or incentivised public transport and the development of an efficient public transport system that is able to cater for the commuting needs of the population. After sufficient pull factors are in place, the push factors can be introduced. These may include road zoning or congestion charging for city areas, as well as an end of life policy for vehicles. Fiscal policy that promotes behavioral change in terms of energy usage in transport, such as carbon tax, CO₂ based Excise Duty etc., should also be implemented. These will discourage the ownership of excessive fuel

consumption vehicles and push the users towards energy efficient vehicles.

For encouraging the usage of rail transport for freight movement, the current rail coverage network needs to be improved. In particular, the integration of road and rail should be improved to ensure seamless transition when delivering goods. The focus on improving energy efficiency of vehicles, energy usage and energy efficiency of the transport sector can be improved if commutation can be reduced or totally avoided. For this, the emphasis on integrated development is important. Proper planning of urban development would ensure easy accessibility and reduce unnecessary commutation. In line with this, transit oriented planning should be continued in NPP3 and implemented. Stakeholders in the workshop also suggested considering policy moves that incentivise or encourage relocation of industries to identified economic regions/strategic areas, such as relocating energy intensive industries to Sarawak Corridor of Renewable Energy (SCORE).

Apart from the development of policies, subsequent action plans must be developed to provide a clear path to implement and monitor the policies. For instance, the transport land use in the NPP can be supported with action plans from related agencies. In the case of land transport, SPAD can play the main role in formulating the action plans.

In the long run, transportation will evolve towards the concept known as Internet of Vehicles (IoV), where vehicles can exchange information between each other or with the environment, and move autonomously. The autonomous operation of vehicles is expected to reduce accidents as well as allow more

efficient energy usage in transportation. It is hence timely for Malaysia to look into this development trend, and come up with a transportation policy that supports the development of IoV.

The stakeholders agree that an Electric Vehicle Policy should be developed as a continuation of NAP 2014, covering the infrastructure planning for electric vehicles. The Electric Vehicle Policy should consider the whole spectrum of the electric vehicle industry, from the source of power to the end-of-life management. In terms of power sources, it should highlighted that power generation from renewable energy sources such as solar, biomass, hydro, etc., must be increased in order to accommodate the power requirements from electric vehicles. If conventional fossil fuel based power generation is used to power these vehicles, electric vehicles would only be else-where emission vehicles and not be helpful in cutting down the CO₂ emission from the transportation sector. At the same time, the policy should support the development of fuel cell technology as one of the potential sources for power for electric vehicles, as there is a vast potential for this technology in improving energy usage and efficiency in transportation. In terms of fuel and emission standards, Malaysia should proceed with its own pace for higher emission standards, on par with international standards.

During the stakeholder workshop, it was recognised that vehicle taxes and incentives would be important for improving energy usage and efficiency in transportation. It was also suggested that taxes and incentive policies could be introduced to phase out inefficient vehicles. For example, lower road taxes or insurance premiums could be offered for more

energy efficient vehicles. At the same time, the scope of vehicle inspection should be extended to cover not just road worthiness but also energy efficiency. Furthermore, manufacturing licenses for commercial rebuilt vehicles, which is currently frozen under NAP 2014, should be stopped all together. Fiscal incentives could be also provided for the adaptation of more efficient modes of transport. For instance, KTM is facing the issue of electricity supplies to run more EMUs. Incentives could be provided to aid the upgrading of facilities such as substations or for the

purchase of spare parts, to encourage EMU usage.

Lastly, it is suggested that mandatory energy usage and fuel efficiency labelling for vehicles should be implemented and the corresponding enforcement policy should be outlined. This will provide more awareness on the impact of energy usage and efficiency in transportation, while promoting the use of more efficient vehicles.

The recommendations/action plans together with the expected implementation timelines are as follows:

PROPOSED RECOMMENDATIONS / ACTION PLANS	STRATEGIES		
	2020	2035	2050
Integrated Transport Master Plan to address the development of the transportation system in Malaysia in a holistic manner. - Focus on the direction of moving from private to public transport, mainly rail based transport. - Transit-oriented development should be the main theme in urban development and needs to be an integral part of the master plan. - Establishment of a Transport Research Centre, and the development of underutilised modes of transport, particularly water transport.. - The use of canals instead of road or railways for transport can be considered. - To move the people from private to public transport, both pull and push factors should be introduced. - Close collaboration between responsible agencies. Stakeholders: MOT, SPAD, KeTTHA, TNB/SEB (check), DOE etc.	X		
Reduce unnecessary energy loss - Policy that incentivises or encourages relocation of industries to identified economic regions/strategic areas, such as relocating energy intensive industries to Sarawak Corridor of Renewable Energy (SCORE). - Use of rail for freight movement to improve transport energy efficiency where possible.		X	

Action plans should be prepared for implementing and monitoring the policies - Eg. develop by the relevant agencies in line with the National Physical Plan 2 (NPP2). SPAD should play the main role in developing the action plans. (Land sector) Stakeholders – all relevant agencies	X		
Internet of Vehicle (IoV) policy. - Autonomous vehicles as a means for improving energy usage and energy efficiency. [2035] Stakeholder – MITI, MOT		X	
Electric Vehicle Policy [2020] - Continuation of NAP2014 - Covers the infrastructure planning for electric vehicles - Development of Fuel cell Technology and Infrastructure Stakeholders: MAI, MOT	X		
Malaysia should proceed with its own pace for higher emission standards, on par with Europe and USA standards. Stakeholders: KeTTHA, MOT	X		
Continue development of biofuel as a source of energy for transportation. Stakeholders: KeTTHA, MOT	X		
Tax and incentive policy to phase out energy inefficient vehicles. - For eg, lower road tax or insurance for more efficient vehicles. - Manufacturing license for commercial rebuilt vehicles should be stopped (currently frozen under NAP 2014) - Fiscal incentives can be provided for the adaptation of more efficient modes of transport. - KTM facing electricity supply issue to run more EMUs. Incentive can be provided to aid the upgrading of facilities such as substations or the purchase of spare parts, to encourage EMU usage. - Vehicle inspection to ensure road worthiness and energy efficiency. - Existing initiatives under the NAP 2014, such as encouraging Malaysia to be the global hub of investment for green power train technology, etc can be reinforced in this policy. Stakeholders: MOF	X		

Implement mandatory energy usage and fuel efficiency labelling for vehicles. Corresponding enforcement policy should be outlined Stakeholders: MITI & MOT	X		
---	---	--	--



Technology

The utilisation of technology is a key means in order to achieve the 2DS by 2050 as envisioned by the IEA. Amongst the efforts taken to mitigate the increasing level of GHGs are through the development of alternative/green fuel technology as well as the electrification of vehicles

4.1 Global Outlook

4.1.1 Fuel Technology

i) Hydrogen Fuel

Hydrogen unlike oil and gas is not a primary energy source, however it is an energy carrier. It is mostly produced using existing energy systems based on different conventional primary energy carriers and sources. In the near future, renewable energy sources

will become the most important of the sources for the production of hydrogen. Regenerative hydrogen and hydrogen produced from nuclear sources or fossil-based energy conversion systems, with capture and safe storage (CCS) of CO₂ emission are almost completely carbon-free energy pathways.

Electrical transportation and hydrogen together represent one of the most optimistic means to achieve an emission-free future based on sustainable energy, complemented by fuel cells, as energy conversion devices that provide a very efficient energy conversion. Hydrogen based fuel cells will be used in a wide range of products, ranging from very small portable devices, mobile applications like cars, delivery vehicles, buses and ships, to heat and power stationary generators as well as applications in the domestic and industrial sector.

The use of hydrogen in internal combustion engines (H₂ ICE) and in fuel-cell systems will produce very low to zero carbon emission and eliminate harmful substances like nitrogen oxides (NO_x), sulphur dioxide (SO₂) or carbon monoxide (CO). Hydrogen and fuel cells offer high efficiencies which are independent of size. Fuel-cell electric-drive trains can provide a significant reduction in energy consumption and regulated emission. They may also serve as Auxiliary Power Units (APU) in combination with internal combustion engines, or in stationary back-up systems when operated with reformers for on-board conversion of other fuels which in turn save energy and reduce air pollution, especially in congested urban traffic.

Figure 4.1 (a) presents a chart of primary hydrogen energy sources, energy converters and possible applications, whereas Figure 4.1 (b) illustrates types of fuel cell technologies, possible fuels sources and applications. Figure 4.1 (a) highlights the variety of sources for hydrogen generation which include coal

gasification, steam reforming of methane or other fossil fuel and subsequently the CO₂ sequestration, nuclear reaction, or electrolysis from renewable energy sources. Some of the sources are not at present readily commercialised or mass produced, however extensive research and improvements in terms of capability and quantity are currently taking place.

Based on Figure 4.1 (b), fuel-cell energy sources are not solely dependent on hydrogen. They can be powered by the other types of fuel such methanol, biogas, natural gas or fossil based fuel. This highlights the independence of fuel cell technology on the hydrogen generation system's maturity. In the transportation sector, fuel cell technology offers benefits not only for ground vehicle applications but also for maritime and air transportation. The adaptability of hydrogen into existing ICE configurations and fuel cell applications is clearly a strong motivation for the use of hydrogen as a primary energy source in the future.

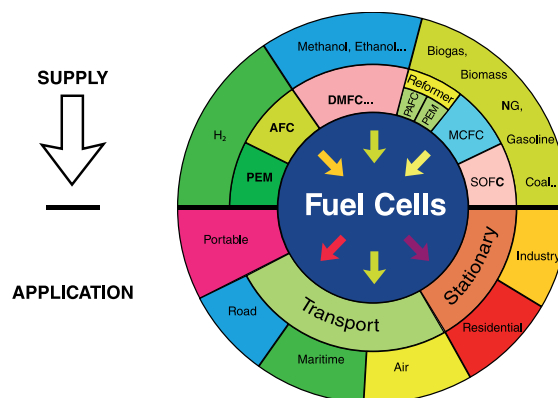
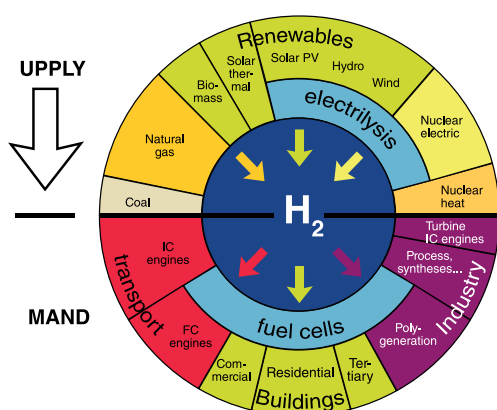


Figure 4.1 (a) (Left) Hydrogen: primary energy sources, energy converters and applications (b) (Right) Fuel cell: technologies, possible fuels and applications

Source: European Commission 2003

- United States Initiatives on Hydrogen**

The U.S. Department of Transportation (DOT) has proposed an estimated timeline for full hydrogen based energy systems for transportation. The proposed action can be summarised into six phases. The proposed timeline does not only indicate the estimated date of completion of each phase but more importantly, it indicates the proposed action which supports the paradigm of the hydrogen economy.

The timeline may be divided into three stages as illustrated in Figure 4.2. Phase I that began in 2000 and ended in 2010 focussed on the coordination of

efforts, targets and funding. The development and testing of prototyped technology especially based on existing ICE configurations and EV architectures were also conducted in this period. Compressed natural gas (CNG) is considered as the main alternative fuel used to develop gaseous fuel technology towards hydrogen. The baseline vehicles used for the study range from the light to heavy duty vehicles. The second phase (2010 – 2020) is the period where the hydrogen is introduced as a vehicle fuel either through dedicated hydrogen fuels or as a blended mixture with other fossil based fuels. Phase III that is expected to take off beyond 2020 will explore advanced technologies as well as the full deployment of hydrogen powered fuel cell vehicles.

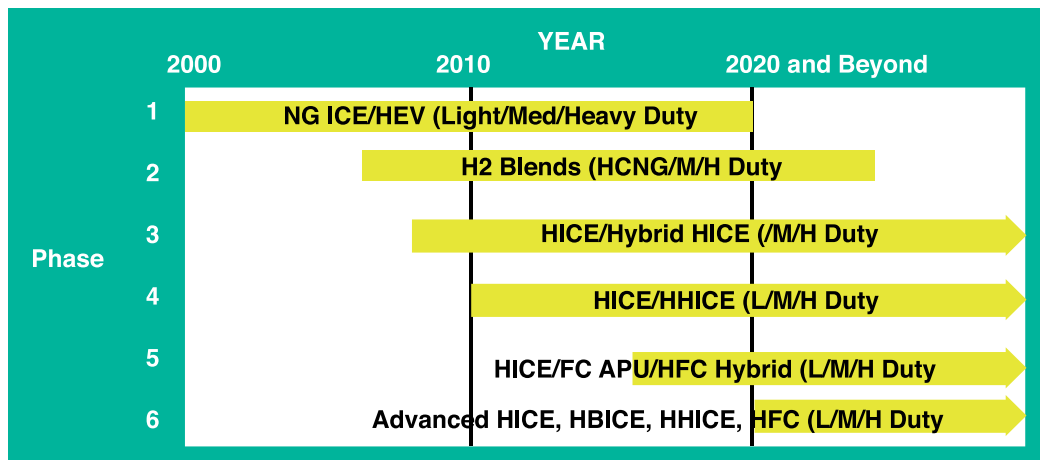


Figure 4.2 Proposed timeline for hydrogen internal combustion engine (H2ICE) by The USA Department of Transportation

Source: http://calstart.org/Libraries/Publications/A_Strategic_Pathway_to_Hydrogen_Fueled_Powertrains_for_Light_Medium_and_Heavy-Duty_Vehicles.sflb.ashx

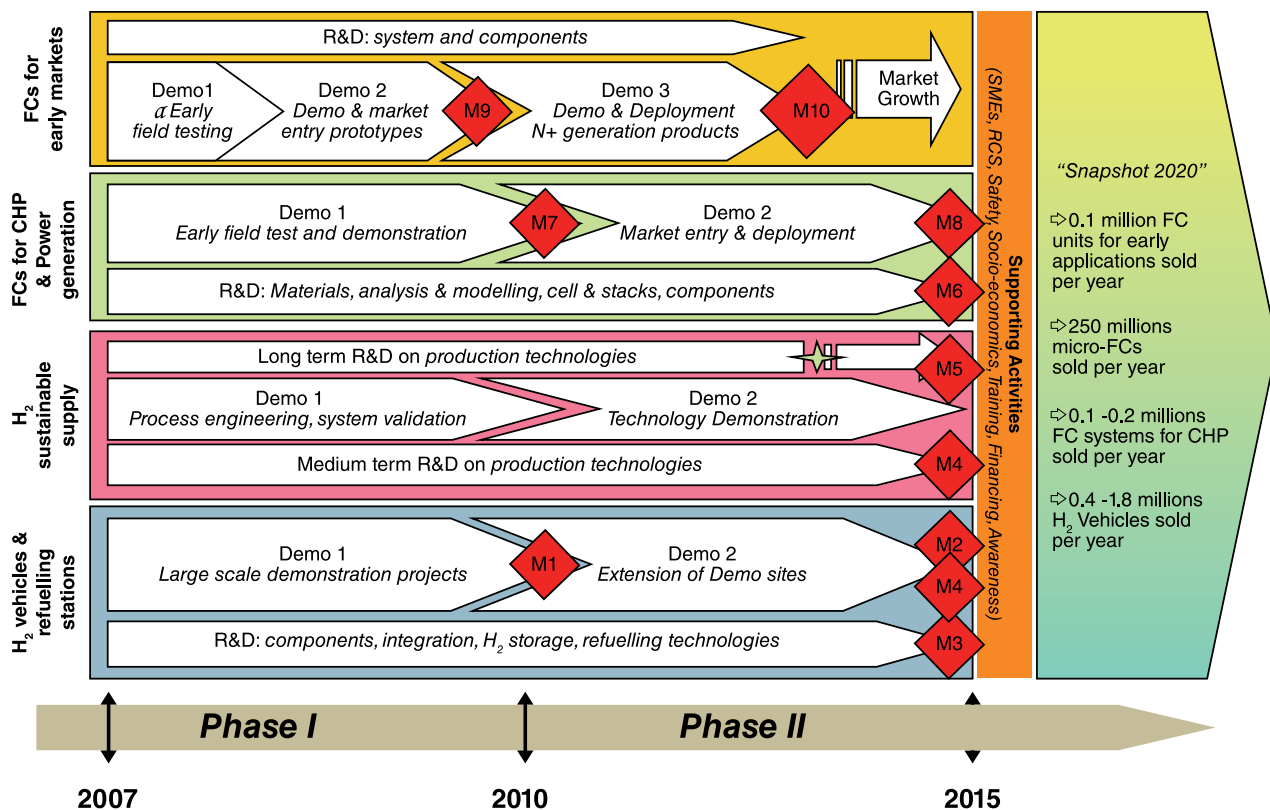


Figure 4.3 European roadmap for development and deployment of H₂ and FC technologies

Source: http://ec.europa.eu/research/fch/pdf/hfp_ip06_final_20apr2007.pdf

The European Commission (EC) has set forth key mechanisms for a new Energy Policy, to ensure sustainable, secure and competitive energy in 2007. The policy incorporates a Strategic Energy Technology Plan and requires an increase of 50 % in energy research to hasten the movement towards a low-carbon, high efficiency energy framework (Figure 4.3). Hydrogen (H₂) and Fuel Cell (FC) technologies were identified to play a significant role in Europe's new energy system. This has led to the formation of the Hydrogen and Fuel-Cell Technology Platform (HFP). The four key elements identified for the Innovation and Development Action (IDA) are H₂ vehicles and

refuelling stations, FC for heat and power generation, sustainable hydrogen supply as well as FC for early markets.

Hydrogen Fuel Cell Status and Barriers

Process and Technology Status

Hydrogen (H₂) can power both internal combustion engines (ICEs) as well as fuel cell vehicles (FCVs). H₂ can be produced directly from fossil fuel and

renewable energy sources or indirectly from water electrolysis. The most economical technique to produce H₂ is through natural gas reforming or coal gasification at a central plant. Nonetheless, these processes produce considerable amounts of CO₂ emission. Therefore, the combination of carbon capture and storage (CCS) technologies in large-scale hydrogen production from natural gas and coal are of paramount importance to ensure environmental sustainability.

Owing to the mature nature of internal combustion engine technology, hypothetically H₂-based ICEs should be relatively simple to be produced at present. However, as hydrogen possesses a low energy density property, the storage of a sufficient amount of hydrogen in the vehicle storage tank in order to achieve a sufficient range of operation is still a critical issue. Conversely, due to the significantly higher efficiency of the fuel cell engines, H₂ storage in fuel cell vehicles (FCVs) is considered to be less of a concern. Nonetheless, FCVs still have overall cost and durability issues which need to be addressed prior to commercialisation. The driving range of FCVs is expected to be comparable to conventional ICE vehicles in the future.

Performance and Costs

Whilst H₂ ICE vehicles that can be produced today are approximately 25% more efficient than conventional spark-ignition vehicles, it is expected that future H₂ FCVs would be at least twice more efficient than conventional vehicles. In terms of cost, the price of H₂ ICE vehicles are almost similar to those of conventional vehicles, however FCVs are unlikely to become competitive in the coming decade as they

require expensive materials (e.g. platinum) as well as other costly components.

Owing to the low density and boiling point properties of hydrogen, on-board storage in either gaseous or liquid form is rather costly and energy-intensive. A significant reduction of carbon emission in transport is possible through hydrogen combustion, however the present primary technique of hydrogen production is a costly and an energy-intensive process. Therefore, hydrogen use is an economical and environmentally affordable option only if its production technologies are cheap and highly efficient.

Moreover, due of the low energy density by volume, the transportation and distribution of hydrogen in comparison with natural gas is also more costly and energy-intensive. Therefore, hydrogen production from on-site water electrolysis at re-fuelling stations or bus depots is not uncommon as it makes a distribution network unnecessary. In order to mitigate the aforementioned issues and to make hydrogen an affordable fuel for the automotive market, research efforts are focussed on lowering costs, improving the efficiency of the hydrogen production processes, reducing the cost of fuel cells as well as developments in hydrogen storage.

ii) Natural Gas

Natural gas drives a variety of sectors in the economy, ranging from electricity generation, industrial heat source, chemical feedstock, and water and space heating in residential and commercial buildings as well as fuel for transportation. Natural gas types differ by the sources or origins of production. Sour gas, shale gas, tight gas and coalbed methane are

amongst the major types of natural gas. Gas that is produced from organic matter is often known as biogas, whilst gas produced from wells is known as the casing head gas. Methane is considered as the core calorific gas in natural gas and forms the major composition of it. Sources of methane are landfill gas, biogas, and methane hydrate. Methane-rich gases that are produced by anaerobic decay of non-fossil organic matter (biomass) are referred to as biogas (or natural biogas).

Shale gas is produced from shale gas wells which depend on fractures to allow the gas to flow. Shale gas has become a major source of natural gas in the U.S. and Canada since 2000 and it has caused the U.S. to become the number one natural gas producer in the world. Shale gas exploration has also begun in countries such as Poland, China, and South Africa.

- World Reserve and Consumption of Natural Gas**

There are abundant supplies of natural gas around the globe that can be developed and produced at relatively low cost. As mentioned earlier, as the U.S. natural gas resources continue to grow, mainly due to the availability of shale gas, it plays an important role in future availability and the price of natural gas. Figure 4.4 illustrates that Russia, Iran and Qatar are the three countries which have the largest natural gas reserves. As of January 1st, 2013, the Oil and Gas Journal records that Russia holds the world's largest natural gas reserves of 1,688 trillion cubic feet (TCF). It is also apparent that Russia's reserves account for approximately a quarter of the world's total proven reserves.

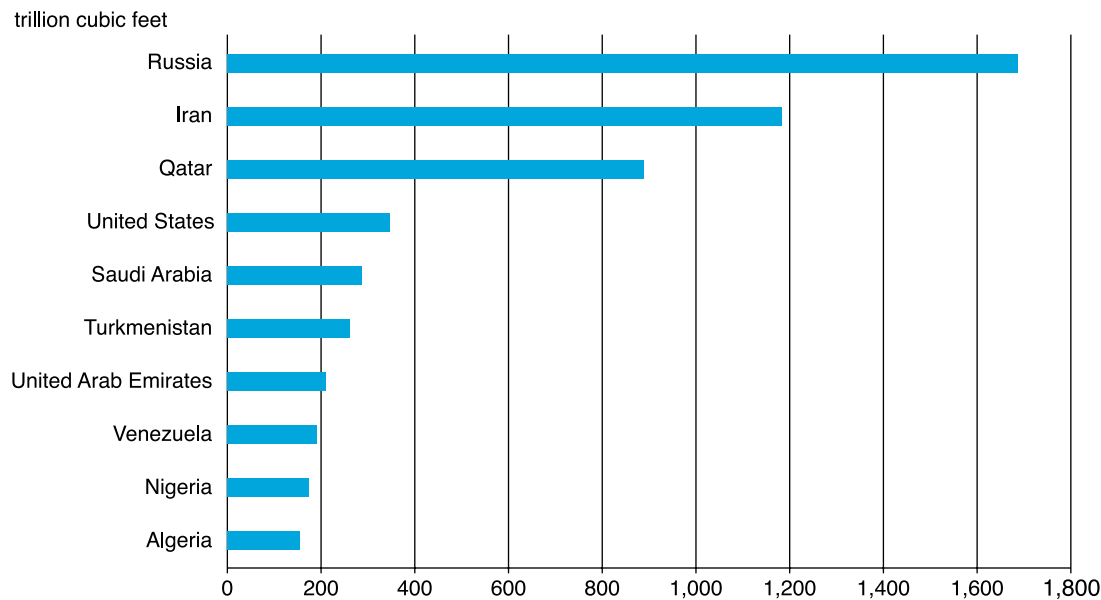


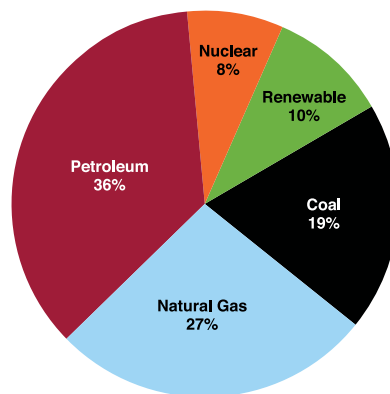
Figure 4.4 Largest proven natural gas reserves by 2013

Source: <http://www.eia.gov/countries/cab.cfm?fips=RS>

As a result of its availability, utility and cost the role of natural gas in the world is likely to continue to expand under almost all circumstances. Its importance is expected to rise even further in order to achieve the objectives of carbon reduction, as it is one of the most cost-effective means by which to maintain energy supplies whilst reducing CO₂ emission.

Natural gas supplies 27% of total energy demand in the U.S. (Figure 4.5) with the industrial sector and electric power generation consuming 33% and 31% of it, respectively (Figure 4.6). The British Petroleum

(BP) Energy Outlook 2014 suggests that the demand for natural gas is expected to grow by 1.9% p.a. over the outlook period, reaching 497 Bcf/d by 2035, with non-OECD growth (2.7% p.a.) outperforming the OECD (1% p.a.) (Figure 4.7). Natural gas will overtake oil as the dominant fuel by 2031, reaching a share of 31% in primary energy in the OECD by 2035. However, gas still remains in third place, behind coal and oil, with a 24% share of primary energy in the non-OECD by 2035. The fastest growing sector projected by this outlook is the transport sector by 7.3% p.a.



Data Source: US Energy Information Agency

Figure 4.5 USA Energy Consumption by Source (2012)

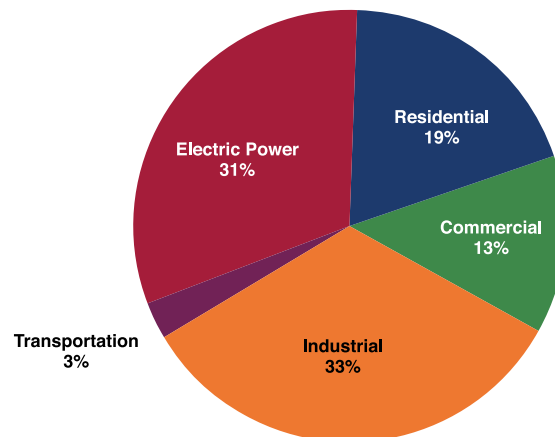


Figure 4.6 Natural Gas Consumption by Economic Sector (2011)

Source: <http://www.c2es.org/technology/factsheet/natural-gas>

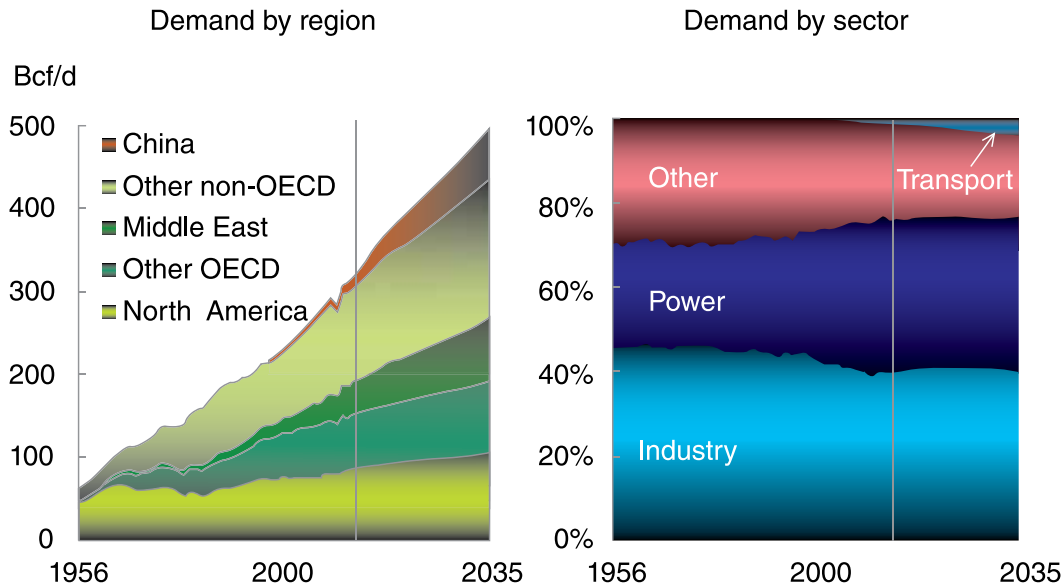


Figure 4.7 Projection of natural gas demand by region and by sector until 2035

Source: <http://www.bp.com/en/global/corporate/about-bp/energy-economics/energy-outlook.html>

• Natural Gas Status and Barriers

CNG vs LNG

Compressed Natural Gas (CNG) is stored in high-pressure tanks in the range of 200 to 250 bar on vehicles. Natural gas is drawn from gas wells or through extraction from crude oil production and comprises mostly of methane. In order to facilitate leak detection of CNG, a sulphur-based odorant is often added. As natural gas is lighter than air, it normally dissipates in the case of a leak, which in turn offers a significant advantage over gasoline or LPG in terms of safety.

Liquefied Natural Gas (LNG) is essentially natural gas stored as a cryogenic liquid between the temperature of -120°C and -170°C . LNG offers an energy density comparable to petrol and diesel fuels, extending range and reducing refuelling frequency, however at the expense of the high cost of cryogenic storage. LNG has been adopted for heavy-duty applications by the USA, Japan, UK and some countries in Europe, however this option is still unfeasible for many developing nations. LNG is commonly used in HDVs as compared to passenger cars as on average passenger cars stand idle more often, which in turn give rise to high evaporative losses.

China and Norway have recently developed LNG marine engines and it is anticipated that this promising move extends LNG technology. Although the LNG fuelled engine is more expensive than a conventional engine, nonetheless it will be a viable investment as LNG is less expensive than diesel. Therefore, it is evident that LNG may pose as a strong economic alternative to diesel in the HDVs, in port facility vehicles, as well as for marine and rail applications.

ANG: New Technology in CNG Storage

Adsorbed Natural Gas (ANG) technology enables the efficient storage of Natural Gas. Adsorption is fundamentally the adhesion of molecules of liquids, gaseous and dissolved substances to the surface of a solid. The ability of a solid to adsorb is subject to the chemical composition of the solid as well as its physical structure. The addition of a microporous material, such as activated carbon which has the ability to adsorb large amounts of NG inherently due to its large surface area, into the storage tank makes it possible to store a larger volume of natural gas in the same container at the same pressure as that of a conventional CNG storage tank.

Nevertheless, the commercialisation of ANG technology is hindered by several unsolved technological problems. The main challenges of ANG storage development are:

1. Sufficient volumetric storage ability which is competing with existing NG storage methods.
2. Efficient gas filling and discharging from the ANG tank for automotive application requires the control of thermo-dynamic processes.
3. The cost of the ANG fuelling system should be as competitive as the cost of existing fuelling systems.

• Heavy and Medium Duty Engine Technologies

The two main engine technologies employed in heavy and medium duty natural gas vehicles are the port injected spark ignited (PISi) engine and High Pressure Direct Injection (HPDI) engine. Both types of engine technology are currently commercially available.

Spark Ignited (SI) engines typically running on CNG are often used in HDVs such as lorries, transit and school buses. The main suppliers of SI engines are Cummins Westport, Doosan Infracore, Emissions Solutions Inc (ESI), Iveco, Daimler, Volvo, MAN, Scania, Shanghai Diesel, Weichai-Petersen and Hyundai. The engine is also available as dual fuel CNG/LNG, however it is only available as a non-certified aftermarket retrofit by Hardstaff.

HDVs that run on natural gas are about 10% less efficient than the ones that run on diesel fuel. The most recent ISL G engine manufactured by Cummins Westport operates either on CNG or LNG, or even on renewable natural gas (RNG). The ISL G complies with the 2014 EPA and California ARB, as well as the EPA and U.S. DOT emission standards without the use of selective catalytic reduction (SCR) or a diesel particulate filter (DPF).

High Pressure Direct Injection (HPDI) engine technology is used in Class 8 lorries (more than 14969 kg GVWR). Westport Innovations modified Cummins engines for HPDI by mainly adding dual fuel injectors (diesel pilot and NG main fuel charge). HPDI engines can be driven up to 1000 km on one fuel charge and possesses the same efficiency as conventional diesel engines. The engines typically cost USD 70,000

more than diesel engines whilst the LNG tanks cost an additional USD 10,000 each (line-haul HDVs typically require 2 LNG tanks). Westport produces up to 2400 engines per year mainly for export to the U.S. and China.

• **Light Duty Vehicles**

The momentum of natural gas Light Duty Vehicles (LDVs) is intensely growing, especially in Asia Pacific as well as North America. The total number of NG LDVs worldwide as of 2013 is 17.5 million and is expected to grow further in key markets such as China, India, Thailand and the U.S. in the coming decade. In the absence of significant OEM offerings an alternative source of NG LDVs is the OEM-approved up fitting of NG technology. Fuel metering/injection technologies are well developed for LDVs and are amongst the notable conversion suppliers globally, including BAF, IMPCO, Baytech, FuelTek and ECO Fuel Systems.

• **Maritime**

The utilisation of natural gas in marine technology currently is at the commercialisation stage. Existing marine diesel engines could burn NG with pilot diesel injection with seamless fuel switching (NG/Diesel/HFO). MAN and Wärtsilä are amongst companies that manufacture large displacement HPDI engines for the large ship market. The preferred NG fuel for marine application is LNG. Therefore, the integration of LNG tanks involves additional costs in both construction and design stage, approximately USD 5 million and USD 100,000 respectively per vessel.

• **Rail**

Natural gas utilisation in locomotive technology has yet to be commercialised. Nonetheless, it has been demonstrated that the common diesel or diesel-electric technology can be adapted to Westport's HPDI technology. Conversely, additional design costs and construction cost must be borne in order to adapt and optimise NG technology in rail applications.

LNG fuel is preferred for rail applications as it is well suited to high-load short-distance operations such as ore or coal hauling. LNG tanks are required to be integrated into trains or railcars in order to provide sufficient fuel supply. It is worth mentioning that such LNG railcars are already available. However, feasibility issues with the LNG technology are prevalent in line haul trains owing to the large distance these railcars require to haul.

As of September 2014, Electro-Motive Diesel, Inc. (EMD) and GE Capital Rail Services (GE) have completed two months of exhaustive testing on LNG fuelled locomotives, with testing equipment that simulates a train hauling 100 cars of coal on the FAST (Facility for Accelerated Service Testing) loop at Transportation Technology Center, Inc. (TTCI) in Pueblo, Colo. Therefore, the deployment of this technology appears to be inevitable in conjunction with the Tier 4 emission compliance.

iii) **Bio-Methane/ Biogas**

Renewable natural gas (RNG) or biogas is another type of methane-based gas with similar properties to natural gas that can be used as transportation fuel. Bio-methane may also be regarded as biofuels. Amongst

the main source of biogas are landfills, sewage and animal/agriculture waste. Biogas may be divided into the following based on its process:

1. Biogas produced through anaerobic digestion which contains mainly CH_4 and CO_2 .
2. Landfill gas collected from landfills has the same composition to biogas upon the removal of trace contaminants.
3. Synthetic Natural Gas (SNG) that is produced via biomass gasification followed by methanation, contains mainly CH_4 .

Cleaned (removal of contaminants) biogas may be converted to CNG or LNG through similar processes, or it may be channelled via natural gas pipelines to serve distant clients, which in turn eliminates storage issues. The cost of biogas, on the other hand, are influenced highly by the level of processing, for instance, biogas for transportation usage requires a much higher quality than the ones used in boilers. The costs of biogas are currently not competitive with natural gas, nonetheless are competitive with diesel/petrol.

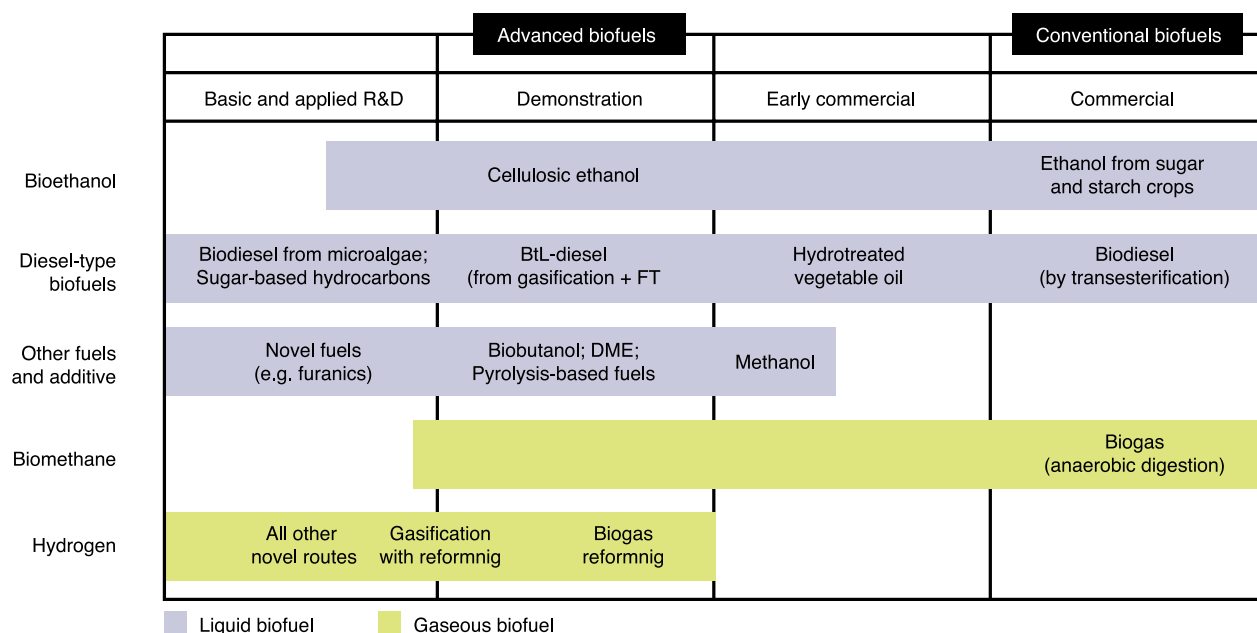


Figure 4.8 Commercialisation status of main biofuel technologies

Source: https://www.iea.org/publications/freepublications/publication/Biofuels_Roadmap_WEB.pdf

iv) Biofuels

Biofuels are often classified into either conventional or advanced biofuel. Conventional biofuel technologies,

commonly known as first generation biofuels has already been well established on a commercial scale. Amongst the first generation biofuels are sugar and starch based ethanol, oil-crop based biodiesel and

straight vegetable oil, as well as biogas derived through anaerobic digestion.

Conversely, advanced biofuel technologies are often known as the second or third generation biofuels are produced using conversion technologies which are still in the research and development (R&D), pilot or demonstration phase. This category includes animal fat and plant oil based hydro-treated vegetable oil (HVO), as well as biofuels based on lingo-cellulosic biomass based biofuels, biomass-to-liquids ((BtL) - diesel and biosynthetic gas (bio-SG). Novel technologies that are mainly in the R&D and pilot stage, such as algae-based biofuels and the conversion of sugar into diesel-type biofuels using biological or chemical catalysts also falls under this category.

The Blending Mandate regulation was applied to OECD countries in order to coordinate and standardise the applied biofuels. Blending mandate is defined as the proportion of biofuel that must be used in road transport fuel. Both OECD and non-OECD countries have adopted blending mandates or targets, whilst several more have announced their interest in adapting biofuel quotas in the near future. Table 4.1 (a) and Table 4.1 (b) present the imposed blending mandates as well as targets.

improving purification of the co-product glycerin as well as through the enhancement of feedstock flexibility.

Whilst the usage of more efficient enzymes and the improvement of the distiller's dried grains with solubles (DDGS) nutritional value may increase the conversion efficiency apart from reducing production costs for conventional ethanol. Through better upstream and downstream integration methods as well as the exploitation of value-added co-product solutions, further cost improvements may well be attained.

Advanced Biofuel

The demonstration of reliable and robust processes within the next five years and achieving commercial-scale production within the next decade are believed to be most critical milestones for commercially viable advanced conversion technologies.

Notwithstanding, the improvement of the overall environmental performance of conventional biofuels, the demonstration of algae-based biofuels as well as other novel conversion routes are also of importance. However, it is worth noting that the effectiveness of such strategies relies heavily on the consolidation of different processes involved throughout the entire supply chain.

• Current Status and Barrier

Conventional Biofuels

Although conventional biofuels are reasonably mature, an inclusive sustainability of the technologies could further enhance better energy efficiency. Amongst the key areas for conventional biodiesel improvement, include increasing catalyst recovery efficiency,

Table 4.1 (a) Overview of biofuel blending targets and mandates

Country / Region	Current mandate/ target	Future mandate/target	Current status (mandate [M]/ target [T])
Argentina	E5, B7	n.a.	M
Australia: New South Wales B2 (NSW), Queensland (QL)	NSW: E4,	NSW:E6 (2011), B5 (2012); QL: E5 (on hold until autumn 2011)	M
Bolivia	E10, B2.5	B20 (2015)	T
Brazil	E20-25, B5	n.a.	M
Canada	E5 (up to E8.5 in 4 provinces), (2012) B2-B3 (in 3 provinces)	B2 (nationwide)	M
Chile	E5, B5	n.a.	T
China (9 provinces)	E10 (9 provinces)	n.a.	M
Colombia	E10, B10	B20 (2012)	M
Costa Rica	E7, B20	n.a.	M
Dominican Republic	n.a	E15, B2 (2015)	n.a.
European Union	5.75% biofuels*	10% renewable energy in transport**	T
India	E5	E20, B20 (2017)	M
Indonesia	E3, B2.5	E5, B5 (2015); E15, B20 (2025)	M

Table 4.1 (b) Overview of biofuel blending targets and mandates (cont)

Country / Region	Current mandate/ target	Future mandate/target	Current status (mandate [M]/ target [T])
Jamaica	E10	Renewable energy in transport: 11% (2012); 12.5% (2015); 20% (2030)	M
Japan	500 MI/y (oil equivalent)	800 MI/y (2018)	T
Kenya	E10 (in Kisumu)	n.a.	M
Korea	B2	B2.5 (2011); B3 (2012)	M
Malaysia	B5	n.a.	M
Mexico	E2 (in Guadalajara)	E2 (in Monterrey and Mexico City; 2012)	M
Mozambique	n.a.	E10, B5 (2015)	n.a.
Norway	3.5% biofuels	5% proposed for 2011; possible alignment with EU mandate	M
Nigeria	E10	n.a.	T
Paraguay	E24, B1	n.a.	M
Peru	E7.8, B2	B5 (2011)	M
Philippines	E5, B2	B5 (2011), E10 (Feb. 2012)	M
South Africa	n.a.	2% (2013)	n.a.
Taiwan	B2, E3	n.a.	M
Thailand	B3	3 MI/d ethanol, B5 (2011); 9 MI/d ethanol (2017)	M
Uruguay	B2	E5 (2015), B5 (2012)	M
United States	48 billion litres of which 0.02 bln. cellulosic- ethanol	136 billion litres, of which 60 bln. cellulosic-ethanol (2022)	M
Venezuela	E10	n.a.	T
Vietnam	n.a.	50 MI biodiesel, 500 MI ethanol (2020)	n.a.
Zambia	n.a.	E5, B10 (2011)	n.a.

B = biodiesel (B2 = 2% biodiesel blend); E = ethanol (E2 = 2% ethanol blend); MI/d = million litres per day. *Currently, each member state has set up different targets and mandates. **Lignocellulosic-biofuels, as well as biofuels made from wastes and residues, count twice and renewable electricity 2.5-times towards the target.

Source: https://www.iea.org/publications/freepublications/publication/Biofuels_Roadmap_WEB.pdf

Key R&D Issues

The industrial reliability, as well as technical performance and operability of the conversion routes,

necessitate the need for specific R&D exercise to achieve economically sound production processes.

Table 4.2 lists the main biofuels as well as its key R&D issues to be addressed.

Table 4.2 Key R&D issue in advanced biofuels

Technology	Key R&D issues
Cellulosic-ethanol	- Improvement of micro-organisms and enzymes - Use of C5 sugars, either for fermentation or upgrading to valuable co-products - Use of lignin as value-adding energy carrier or material feedstock
HVO	- Feedstock flexibility - Use of renewable hydrogen to improve GHG balance
BtL-diesel	- Catalyst longevity and robustness - Cost reductions for syngas cleanup - Efficient use of low-temperature heat
Other biomass- based (diesel/ kerosene fuel)	Reliable and robust conversion process in pilot and demonstration plants
Algae-biofuels	- Energy- and cost-efficient cultivation, harvesting and oil extraction - Nutrient and water recycling - Value-adding co-product streams
Bio-SNG	- Feedstock flexibility - Syngas production and clean-up

(Source: https://www.iea.org/publications/freepublications/publication/Biofuels_Roadmap_WEB.pdf)

4.1.2 Electrification of Transportation

An electric vehicle (EV) is essentially a vehicle driven by an electrical propulsion system. EVs offer the prospect of zero vehicle emissions of GHGs, air pollutants, as well as low noise levels. Its high efficiency and relatively low cost of the electric motors provides added advantage against conventional ICE vehicles. Nonetheless, the main drawback of EVs

stems from their reliance on batteries that currently have low energy and power densities as compared to conventional oil based fuels which in turn results into restricted range, increased recharging time and cost.

i) Electric Vehicle Configuration and Current Status

Electric vehicle may further be classified into the following categories in terms of the source of power for the propulsion system:

- 1) Batteries electric vehicle (BEV)
- 2) Hybrid electric vehicle (HEV)
- 3) Plug-in hybrid electric vehicle (PHEV)
- 4) Fuel cell Electric vehicle (FCEV)

BEV is considered as a fully electric vehicle as the propulsion system is driven by the electrical energy stored in rechargeable batteries. Amongst the world's top selling BEVs includes Nissan Leaf (150,000 units sold as of November 2014), Tesla Model S and Roadster (52,500 units sold as of October 2014) as well as Mitsubishi i-MiEV (32,000 units sold as of June 2014). FCEVs are powered by the generation of electricity through electrochemical reaction. Although there have been a variety of fuel cells developed, the cost of hydrogen generation to fuel the electrochemical processes impedes its wide commercialisation (to date Toyota Mirai and Hyundai ix35 FCEV are commercially available).

HEVs exploit the use of both reciprocating engine and electrical propulsion motor interchangeably or continuously parallel in its operation. HEVs may be further classified as full hybrids (e.g. Toyota Prius, Ford Escape Hybrid, and Ford Fusion Hybrid) and mild hybrids (e.g. first generation of Insight and Chevrolet Silverado Hybrid), where the former can either run on just engine, batteries or the combination of both, whilst the latter could not be driven solely by its electric motor. PHEVs, on the other hand, are hybrid electric vehicles with rechargeable batteries that can

be restored to full charge by connecting a plug to an external electric power source. Such PHEVs are commercially available, for instance, Chevrolet Volt (over 87,000 units sold up to November 2014), Toyota Prius PHV (over 65,300 units as of September 2014) and the Mitsubishi Outlander P-HEV (33,000 units sold as of June 2014).

Although the sales of BEVs and HEVs at large are improving, more is required to achieve the 2DS by 2050. ETP 2014 predicts that the annual sales for both EVs and HEVs must increase to up to 80% and 50% respectively by 2020 in order to attain the aforesaid goal. A study conducted by Offer et al., 2010 on the predictions made by IEA on BEVs and FCEVs by 2030, suggests that FCEVs could play an important part in future road transport. However, the study further suggests that fuel cell integration with BEV would likely be the best platform rather than ordinary FCEVs and the technology roadmap could begin with plug-in ICE hybrids.

ii) Electric Vehicle Key Technologies

• Electric Motor

At present, the interior permanent magnet (IPM) synchronous motor is extensively used in automotive propulsion owing to its high efficiency, high torque, high power density, and relatively ease of field weakening operation. Toyota Prius, Ford Escape, and Chevy Volt are amongst the vehicles that utilise this technology. Nonetheless, there is a great anxiety surrounding the technology behind the IPM based models that are currently being used in most EVs and HEVs, namely the availability of rare earth-

based magnets and their increasing cost. Therefore, extensive research works on other viable options for electric propulsion, such as the induction motor, switch reluctance motor, synchronous reluctance motor (SynRM) as well as permanent magnet SynRM are currently underway.

For instance, there has been a renewed interest in the use of induction motors for electric vehicles. By eliminating the use of magnet in the rotor, induction machines are not only cheaper, but also more reliable as there is no risk of demagnetisation. Tesla has demonstrated the commercial value of induction motor driven electric vehicle in its Roadster model. By using copper rotor rather than aluminium rotor, Tesla Roadster demonstrated significant improvement to the motor efficiency, claiming a driving efficiency (battery to wheel) of 88%, approximately 3 times of a conventional car. (Tesla motors, n.d.).

In conventional hybrid or full electric vehicles, the traction power from the electric motor is transmitted to the wheel via gear-shaft systems. However, such mechanical transmission is known to create additional power losses and require maintenance from time to time. By having the motors directly within the wheels, i.e in-wheel motors or wheel-hub motors, the mechanical transmission can be removed. This not only reduces power losses, but also improves space utilisation. Several companies, such as Protean Electric, Mitsubishi, Citroen etc., have developed concept cars based on these in-wheel motors. In Malaysia, researchers in UMPEDAC from University of Malaya have been developing permanent magnet hub motor for electric vehicle applications while UTHM are developing flux-switching motors.

While most of the existing electric motors are three phase machines, there are some motivations to use motors with higher number of phases to improved reliability and power density. The restriction to use single-phase or three-phase machines is mainly due the fact that the available power supply is either single-phase or three-phase in nature. However, for electric vehicles whose motors are driven by power electronics converter, it is possible to use motors with higher number of phases. Various investigations on multiphase machines and drives are actively being conducted (Levi et al., 2008). Compared to three-phase motors, multiphase motors can continue to operate with fault in one or more of their phases, providing a higher degree of reliability and robustness. In terms of actual industrial uptake, multiphase motors have been used in transport applications such as high speed elevator (Jung et al., 2012) and aircraft taxing (Chorus Motors, 2010). In Malaysia, researchers in UMPEDAC from University of Malaya have been working with control of six-phase induction machines.

• Power Electronics

Power electronics is the key for the development of EV and HEV propulsion systems. Nevertheless, the challenges lie in obtaining a high-efficient, rugged, small size, and low-cost inverter and the associated electronics for controlling a three-phase electric machine as they are required to withstand thermal cycling and extreme vibrations. The conventional topology being used in both EVs and HEVs is the three-phase hard switched bridge inverter due to its simplicity and established nature.

Further improvements in the technology, led to the use of two 3-phase inverters that consists of 48 MOSFETs for each phase leg of the inverter. Nonetheless, almost all commercially available EVs, HEVs, and PHEVs uses IGBT devices that replace the MOSFETs. Although SiC is understood to be the most preferred next-generation power semiconductor devices that would replace the existing silicon technology, GaN devices are expected to have considerably higher performance over silicon-based devices even SiC devices. This is mainly due to its excellent material properties that lead to a substantial reduction in both conduction and switching losses.

Currently, there are several established research centres/clusters among the local institutes of higher learning in Malaysia who are working in the areas of power electronics and drives. These include UMPEDAC from University of Malaya and Proton Future Drive Lab in UTM.

- **Energy Storage System**

Energy storage system is a rather crucial aspect in the development of EVs. The power density, energy density, weight, volume, cycle life, and cost are the main considerations in the battery selection for EV applications. Other non-trivial considerations include the operating temperature range, safety, material recycling, and maintenance.

Lithium-based technologies and lithium-ion batteries are leading the way in meeting the requirements of EV/HEVs as they have the potential to deliver 400- to 450-W hours of electricity per kilogram. These batteries are able to produce high output energy and

power per unit of battery mass, which in turn, allows them to be lighter and smaller than other rechargeable batteries. Lithium-ion batteries are currently being used in Nissan Leaf EV and GM's Chevy Volt plug-in EV.

Lithium-air technology is understood to be the future of EV battery as such batteries could significantly increase the range of EVs owing to their desirable high energy density. It is theoretically estimated by researchers that its energy density is to be of equal to the energy density of petrol. It is also expected that these batteries could hold to up to 10 times the energy of lithium-ion batteries of the same weight and twofold the energy for the same volume. Nonetheless, amongst the present drawbacks of lithium-air batteries are their limited number of charge/discharge cycles as well as their relatively slow charging process as compared with the conventional lithium-ion batteries.

In terms of research in Malaysia, the Advanced Material Research Centre (AARC) in SIRIM has been developing Lithium-ion battery, suitable for portable power sources, including electric vehicles.

- **Battery Charging**

Current plug-in and EVs are designed primarily for home charging using either Level 1 (2 to 5 miles of range per hour charging) or Level 2 (10 to 20 miles of range per hour charging) chargers which charge using AC supply with the charger units that use 120 V or 240 V AC are often installed on the vehicle. Electric vehicle supply equipment (EVSE) must be installed by EV owners at their home to link home energy management system (HEMS) with the on-

board chargers. The Level 3 (60 to 80 miles of range per 20 minutes of charging) chargers are off-board and use DC charging commonly referred to as DC fast charging.

A new concept for EV charging known as the combined charging system have developed by a number of automotive manufacturers working with Society of Automotive Engineering (SAE) and other organisations. This system allows the integration of AC charging and ultra-fast DC charging in a single system and HomePlug Green PHY PLC has been selected as the communication standard for the universal charging system that supports both AC charging and fast DC charging in EVs.

A number of companies are also working on inductive charging that uses an electromagnetic field to charge the batteries in order to address the range anxiety issue. This method of charging eliminates the EV power cord. BMW and Nissan are working towards the implementation of this option, allowing their vehicles to be charged in embedded charging stations that are available in parking lots as well as on the road.

Delphi a leading global electronics supplier is developing a wireless charging system that will enable wireless energy transfer. This highly resonant magnetic coupling hands-free charging technology will efficiently transfer power over significantly larger distances as compared with inductive systems and is said to fully as fast as four hours.

The design and control of effective battery charger is a topic of active research among many research centres in Malaysia, including UMPEDAC and UTM Proton Future Drive Lab.

4.1.3 Revolutionary Transportation System

Revolutionary transportation system such as the Advanced Transit Networks (ATN) offers an alternative solution to provide a more environmentally sustainable mode of transportation as compared to existing public transport modes. Apart from emitting very low noise and vibration, as well as no local emissions, it harnesses the benefits of technology by reducing the use of cars and conventional public transport. ATN embraces various concepts namely personal rapid transit (PRT), group rapid transit (GRT) as well as dual mode systems which ensures green mobility whilst offering door-to-door transit for small group or individuals through interconnecting public transit networks.

PRT system operates on a network of dedicated guide ways by small automated vehicles that could accommodate a maximum of four adults and two children. This system provides direct connections and usually operates on demand. Amongst cities that have deployed the PRT systems are Masdar City, Abu Dhabi, Heathrow Airport, UK, Suncheon South Korea and it is expected to begin operations at Amritsar, India in 2015.



Figure 4.9 ULTra PRT that facilitates the journey between the stations at the business car parks and Terminal 5

Source: <http://www.advancedtransit.org/advanced-transit/applications/>

GRT systems on the other hand feature larger vehicles installed both in line and network configurations that could accommodate up to 25 passengers. It offers mid-ground between mass and personally oriented systems. Amongst places that have employed such system are West Virginia University, Morgantown, USA, and Rivium Business Park, the Netherlands. Recently, 2getthere and

Hsin-Chu Seamless Joint Co., Ltd. has signed a Memorandum of Understanding on the 30th January on the realisation of the Hsinchu GRT connection that links local rail stations in the Hsinchu district with National Tsing Hua University and Hsinchu Science Park, Taiwan.



Figure 4.10 The ParkShuttle GRT that connects business park Rivium and the residential area Fascinatio

Source: <http://www.advancedtransit.org/advanced-transit/applications/rivium/>

Dual-mode systems or dual mode transit (DMT) aim to combine the possibility of automated driving with the manual control by a driver. The automated mode of the system ensures the most efficient use of space when it enters guide ways, whilst it also

accommodates in other areas where personal control is required namely on public roads. Such system is has been implemented in Japan by the JR Hokkaido Railway Company in 2007.



Figure 4.11. JR Hokkaido Dual Mode Vehicle (DMV)

Source: <http://i-love-japanese.blogspot.com/2010/09/apakah-itu-bis-atau-kereta-api-itu.html>)

Maritime

Electrifying long-haul shipping is seen to be a futile exercise in the short term, nonetheless limited savings could be attained through port electrification as ships berthed. This shore to ship power solution allows the reduction of GHGs and noise emissions, as well as vibrations apart from costs savings as engines can be turned off.

The Association of Electrical and Medical Imaging Equipment Manufacturers reported that Los Angeles, Seattle and Vancouver are following suit the move by California in reducing emissions on port emissions. Norway is also considering the prospective of battery swapping for a full electric ferry with a recharging time of less than ten minutes (Barry, 2013a). Denmark has

demonstrated the high possibility of hybridisation for frequent ferries.

The viability of partial electrification of yacht through photovoltaic (PV) cells was successfully demonstrated by the MS Tûranor PlanetSolar. Although there is increased interest in the electrification of shipping, the prospect of it to materialise in any mainstream commercial applications are unlikely to occur prior to 2030.

Aviation

The electrification trend on aircrafts is expected to increase as it has resulted in significant fuel savings, however, full fuel switching is not likely to transpire apart from for small, very light-body aircraft. The Israeli

airline, El Al Airlines converted 20 of its Boeing 737s enabling them to utilise hybrid electric power whilst on the ground. The utilisation of auxiliary power unit instead of the primary engines whilst operating during taxiing and idling was found to reduce fuel usage by 85%.

Plug-in aircraft is expected to be commercially available by 2040 as suggested by a report prepared by NASA/Boeing. A plug-in hybrid concept aircraft with an on-board battery for regional short-haul flights is currently underway under the SUGAR Volt (Boeing) project. Electric aircrafts appear to be ahead of plug-in-hybrid with the maiden flights of Airbus's E-Fan and Aero Electric Aircraft Corp.'s Sun Flyer Electra One aircrafts amongst others.



Figure 4.12 Airbus Group's E-Fan

Source: <http://insideevs.com/electric-e-fan-gets-airborne-first-public-flight/>

The E-Fan has successfully completed its first electric aircraft public test flight in March 2014. The aircraft's 30kW engines, powered by 250 V lithium-ion polymer batteries is able to fly for 37 minutes as of July 2014. Conversely, Sun Flyer Electra One is a 2-seater solar-electric light sports aircraft that flies on

two electric motors and Panasonic lithium batteries, opens up new dimension on the solar-electric aircraft propulsion technology.



Figure 4.13 Sun Flyer Electra One

Source: <http://insideevs.com/sun-flyer-first-flight-demonstration-videos/>

i) Improving Vehicle Efficiencies

The improvement on the efficiency of existing transportation system is essentially the most cost-effective and reliable method to overcome the fossil fuel depletion apart from more stringent emission regulation. Newer policies and regulation that will be enacted in the future are subjected to the existing efficiency of energy utilisation and transportation system.

The European Road Transport Research Advisory Council (ERTRAC) has outlined the following objectives to improve the efficiency of future European transportation system:

- a) Better vehicle efficiency through **advanced cleaner propulsion technologies**, including the adaptation of alternative energies

- b) Better vehicle efficiency through **reductions in weight** and in **aerodynamic** and **rolling resistance**
- c) **Reducing rolling resistance** by optimising **tyre materials, shape, inflation**, without compromising performance, and taking into account the tyre-pavement interaction
- d) Reducing energy consumption and carbon footprint through **smart and sustainable usage**
- e) **Developing the next generation of transport means** as the way to secure market shares in the future
- f) **On board and smart control system**

The U.S. Department of Energy through its Vehicles Technologies Programme aims at deploying clean, efficient vehicle technologies and renewable fuel through:

- a) **Hybrid Electric Systems** R&D (e.g., energy storage, electric drive components, and systems analysis and testing)
- b) **Advanced Combustion Engine** R&D on existing ICEs efficiency as short term cost-effective approach to increase fuel economy
- c) **Materials Technology** which looks into lightweight, high-performance materials that improves fuel economy without compromising its safety features as well as the improvement on propulsion materials
- d) **Fuel Technology** R&D that focuses on competitive fuel options that delivers lower emissions and higher fuel economy
- e) **Technology Integration and Deployment** that engages the stakeholders as well as supporting relevant legislative activities

4.2 Current Status in Malaysia

In 2009, the Malaysian government has pledged a conditional voluntary target of 40% reduction in the CO₂ emission intensity per unit of Malaysian GDP by 2020 against a 2005 baseline, at the UN Climate Change Summit, Copenhagen. One of the means to achieve this pledge is through the reduction of GHGs emission from transportation apart from the built environment and the energy production sector. Besides the enactment of policies, various initiatives have been taken by the Malaysian government through the utilisation of technology to honor the pledge as well as in playing its part to meet the 2DS envisaged by the IEA.

4.2.1 Fuel Technology

i) Fuel Cell Technology

Hydrogen and fuel cell technologies in Malaysia are relatively still at its research phase as commercialisation of hydrogen or fuel cell related technology has yet to be realised until today. R&D on hydrogen and fuel cell are conducted separately by a few research groups at different university or research institutes at different stage of maturities. Studies on hydrogen as additives fuel to CNG has been conducted by Center for Automotive Research, Universiti Teknologi PETRONAS (UTP). The outcome of their research has produced hydrogen additives that improve engine performance in terms of Brake Specific Energy Consumption (BSEC) and cylinder pressures, as well as low emissions at low engine speed.

The first dedicated fuel cell and hydrogen energy research institute, Fuel Cell Institute (Institut Sel Fuel), was founded in 2006 at University Kebangsaan Malaysia (UKM). UKM started the construction of the first proton exchange membrane fuel cell in Malaysia made from Nafion membrane donated by Dupont (M) Sdn Berhad, carbon paper electrodes and perspex plates in 1995. This effort was followed suit by Universiti Teknologi Malaysia's (UTM) Institute of Hydrogen Economy, which carries out scientific research on hydrogen generation, hydrogen fuel cell application, process safety, improving process efficiency and novel fuel cell materials. As one of the

center of excellence on power and energy, UMPEDAC from University of Malaya is developing the power electronic converter for effect control of fuel cell power.

Malaysia's first Hydrogen Fuel Cell vehicle was launched by Education Minister II Datuk Seri Idris Jusoh at UKM on the 4th of December 2014. The vehicle in a form of a golf buggy is powered by a fuel cell engine using a system known as a Proton Exchange Membrane (PEM) Fuel Cell/Supercapacitor Hybrid Power. It is expected that a passenger car prototype will be built by 2016



Figure 4.14 Tun Mahathir Mohamad test drove Malaysia's first Hydrogen Fuel Cell vehicle accompanied by Prof Ir Datuk Dr Wan Ramli Wan Daud, FASc on January 12th, 2015

Source: <http://www.ukm.my/news/index.php/en/extras/1997-tun-mahathir-test-drove-malaysias-first-hydrogen-fuel-cell-vehicle.html>

ii) Natural Gas

The development of Natural Gas Vehicle (NGV) in Malaysia began nearly three decades ago with a project of natural gas vehicles pioneered by a small group taxi cars in Kuala Lumpur. This project is considered a success to Malaysia as a developing country that ventures into this technology development. PETRONAS was the focal organisation to embark the development of NGV in Malaysia.

The pilot program was implemented by PETRONAS in 1986 to 1988 in Kertih, Terengganu and subsequently was implemented in the Klang Valley in 1991, through the Natural Gas for Vehicles Program (NGVP). PETRONAS NGV (PGNV) Sdn Bhd then was established on February 14, 1995 to spearhead promotion and development of NGV in Malaysia. As of January 2015 there are 183 NGV fuelling sites across Malaysia. The Malaysian NGV (MNGV) Sdn Bhd under the brand name 1GAS is expected to further increase at least 100 NGV fuelling stations by 2016.

UTM has conducted research on Compressed Natural Gas (CNG) application for passenger vehicles. The CNG system was based on an external mixer and port injection for mixture preparation. It was found that the CNG fuel reduced the regulated emission produced by vehicle as compared to petrol and diesel engine. However, significant power and torque loss were noticeable. A joint research program on CNG fuel was then initiated, which comprised of Universiti Malaya (UM), UKM, Universiti Putra Malaysia (UPM) and UTP. The major objective of the program is to develop high-pressure direct fuel injection technology (HPDI) for CNG fuelled vehicle. A number

of achievement have been recorded under the project with multiple new technologies have been patented.

UKM has developed the Spark Plug Fuel Injection system which enabled the CNG-DI application on existing engine configuration with moderate engine modification. UTP has successfully tested engine performances using Hydrogen-CNG (HCNG) blended fuel using in-situ mixing approach. UM has developed a retrofit direct injection system using gasoline (petrol) direct injector. Two types of injection system have been demonstrated, namely top injection and side injection system that operates in pressure range of 20 bar to 55 bar. Although, today CNG has become the main contending alternative fuel in Malaysia, the mixing technology for CNG are still based on external mixture formation system which is less efficient as compared to the HPDI system.

iii) Biodiesel

The Malaysian Government launched its National Biofuels Policy in 2005 with the aim of positioning Malaysia as a major global biodiesel producer. Amongst the five key thrust of this policy are biofuel for the transport sector, biofuel the industrially sector, biofuel technologies, biofuel for export and biofuel for a cleaner environment. Biofuel production in Malaysia is synonymous with palm oil, a major established agricultural product in Malaysia. There are two methods of producing biofuel from crops oils, namely the conventional method and the direct blending of straight vegetable oil (SVO) with petroleum diesel.

The conventional method is through trans-esterification, which produces methyl esters or PME

(biodiesel) that can be used in compression ignition engines (diesel engines) without any modification. In 1992, palm biodiesel production technology was successfully developed including winter-grade biodiesel. Although considerations were given to increase its usage domestically, the PME grade biodiesel was produced for the export market. Overseas trials on PME include running diesel-powered commercial trains in Germany.

The SVO blend of 5 percent refined palm oil and 95 percent petroleum diesel was marketed under the name Envo Diesel. Nonetheless, the Envo Diesel faced resistance from automobile manufacturers, who were hesitant to extend engine warranties when palm olein rather than methyl ester is used in blending. Owing to the resistance, Envo Diesel was short-lived as the government decided to replace it with PME based biodiesel in 2008. As of December 2014, the PME based biodiesel was fully sanctioned nationwide under the name B5 Diesel.

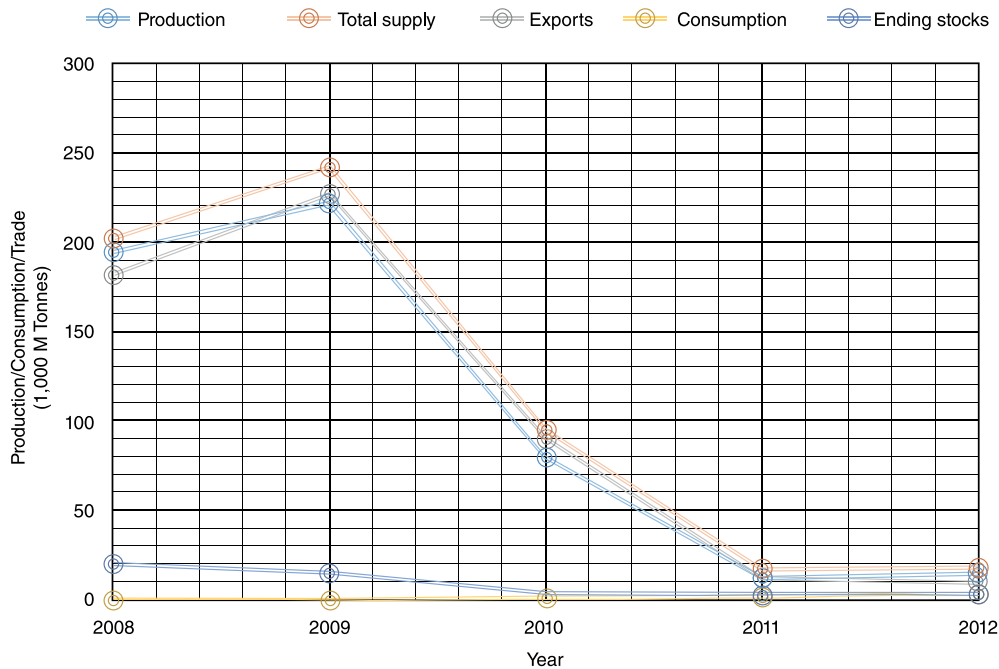


Figure 4.15 Malaysia Biodiesel production/ consumption/trade by Year (2008-2012)

Source: http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Kuala%20Lumpur_Malaysia_7-9-2013.pdf

iv) Biomass/Bio-Natural Gas

SIRIM's palm oil mill effluent (POME) BioNG project is ready for commercialisation. The culmination of the eight year research project is the development of a pilot plant on Carey Island, Selangor built in 2013 that was established in cooperation with Sime Darby Research. BioNG is as versatile and efficient as petroleum natural gas. BioNG is expected to not only immediately reduce the amount of GHGs released by Malaysia's palm oil industry, but also is able to reduce the use of hydrocarbon based liquefied natural gas (LNG) in Malaysia's energy and transportation sectors as BioNG possess almost identical chemical composition as well as energy density of LNG. SIRIM is currently extending a proposal to the Finance Ministry to release a fund of RM12 million to build the world first bio-natural gas (BioNG) demonstration plant in Sabah that is able to produce approximately 5,000 cm³ per day, ten folds the capability of the pilot plant.



Figure 4.16 Different Phases of Palm Oil Production

Source: Cultivation to Biodiesel Production, Mohd Basri Wahid, presentation slides Malaysian Palm Oil Board



Figure 4.17 Bio-natural gas vehicle prototype and prototype fuelling pump

Source: <http://www.sirim.my/product-highlights/123-product-highlights/214-bio-natural-gas>

Table 4.3 Characterisation of Vehicles based on specification (Source: NAP 2014)

SEGMENT	DESCRIPTION	KERB WEIGHT (kg)	FUEL EFFICIENCY (l/100 km)
A	Micro Car City Car	< 800	4.5 5.0
B	Super Mini Car	801-1,000	6.0
C	Small Family Car	1,251-1,400	6.5
D	Large Family Car Compact Executive Car	1,401-1,550	7.0
E	Executive Car	1,500-1,800	9.5
F	Luxury Car	1,801-2,050	11.0
J	Large 4x4	2,051-2,350	11.5
OTHERS	Others	2,351-2,500	12.0

4.2.2 Energy Efficient Vehicles*

NAP 2014 unveils the government's plan for making Malaysia in becoming a regional hub for EEVs through strategic investments and adaptation of high technology for domestic market as well as regional and global market penetration by 2020. MAI defined EEVs (including HEVs and EVs) through the NAP 2014 as vehicles that meet specific fuel consumption and carbon intensity levels, however to date the intensity levels have yet to be defined.

The NAP 2014 grants locally manufactured EEVs customised incentives that include grants and tax breaks, leads to lower prices for the consumer. Introduction of Perodua Axia, the first locally produced EEV showed tremendous potential in terms of sales, hitting 62,000 bookings in the first three months of its inception. The vehicle incorporates an array of improvements such as reduction in vehicle weight, reducing engine load by converting hydraulic steering drive to electric without sacrificing safety and sufficient engine power. Amongst recently qualified vehicles as EEVs according to the NAP 2014 are Honda Jazz and City.

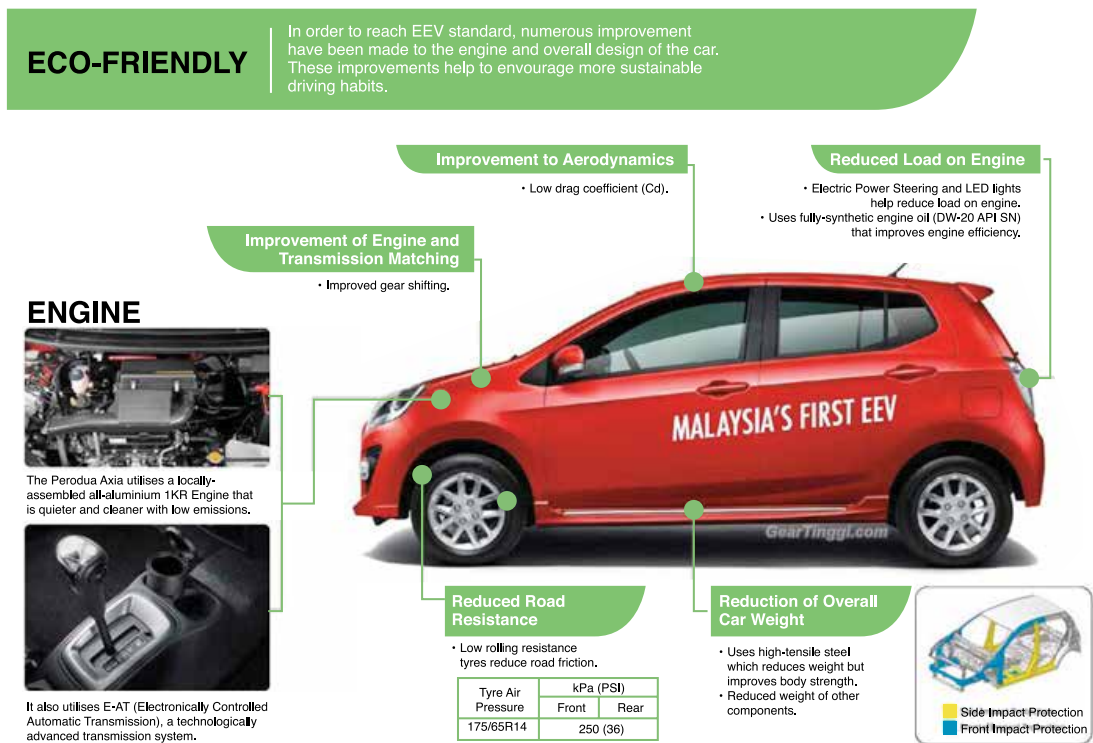


Figure 4.18 Perodua Axia fuel economy description

Source: <http://paultan.org/2014/09/15/perodua-axia-launched/axia-booklet3-ol-11/>

* In this report, EEVs are defined as conventional engines with improved efficiency excluding any form of EVs.

Go Automobile Manufacturing Sdn Bhd (GAM), the first local company granted with EEV license following the NAP 2014 execution last year has recently launched the first sports utility vehicles (SUVs) EEV, Great Wall M4. Mazda is the other automaker that has been given EEV manufacturing licence apart from Perodua and Great Wall for their SkyActive cars. BMW Malaysia has also shown interest in making Malaysia its EEVs manufacturing and regional hub. They have submitted their proposal to the Malaysian government April last year.

4.2.3 Vehicle Electrification

The penetration of electric vehicles (EVs) which includes hybrid electric vehicles (HEVs) and battery electric vehicles (BEVs) in Malaysia is very much driven by policies. The NAP 2009 was instrumental towards promoting hybrid & electric vehicles and the development of related infrastructure. The number of sales of EVs in Malaysia saw a dramatic increase of 4839 units in 2011 as compared to 138 units in the previous year. An increasing trend could be observed in the subsequent years with Japanese manufacturers, Honda and Toyota continue to share the largest market shareholders for electric vehicle segment. On the top of the chart, the most affordable HEVs in Malaysia market is the Honda Insight, followed by Honda Civic Hybrid and Toyota Prius.

Table 4.4 Hybrid and Electric Vehicle registration data based on year

Vehicle Category	Total Registered by Year			
	2010	2011	2012	2013*
Hybrid	138	4,702	8,772	13,506
Electric	-	275	183	193
Total	138	4,977	8,955	13,699

(*Data until 31st December 2013.)

Source: MAA

Mitsubishi officially launches its full EV vehicle, i-MiEV on March 2013 after initial registration in 2011 to promote zero-emission EVs and its Eco-Tourism Pilot Demonstration Programme at Four Seasons Resort, Langkawi in 2012. The Nissan Leaf became the second EV available for sale in Malaysia. First Energy Networks (FEN) to date has set up 40 (As of December 2014) public EV charging the Klang Valley, Penang, Melaka and Johor Bahru. It is expected that in 2015, 300 more EV charging stations will be erected by FEN and funded by the Malaysian Electricity Supply Industries Trust Account (MESITA).

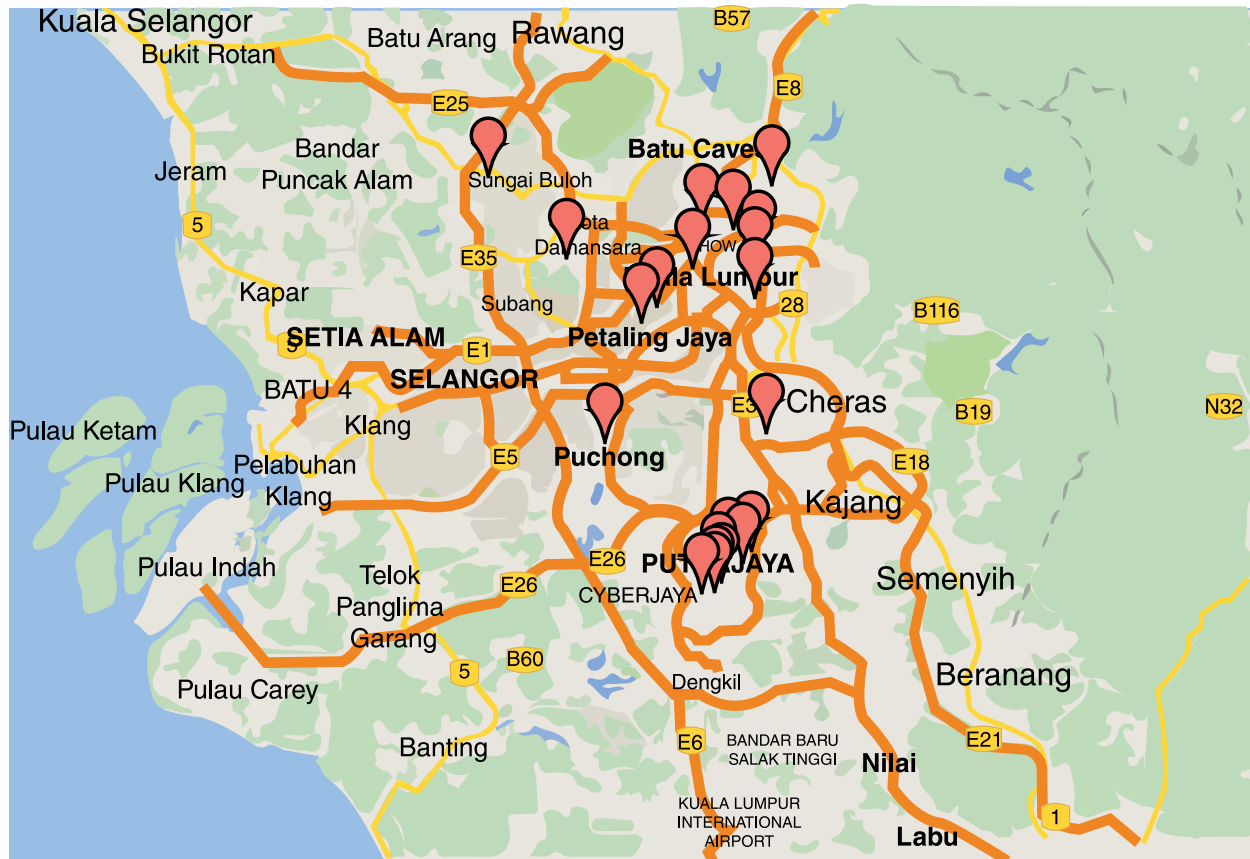


Figure 4.19 EV charging facilities available in KL and Klang Valley

Source: <http://leapingpost.com/2013/11/23/electric-vehicle-charges-malaysia/>

In 2010 and into 2011, prototypes of the Range Extender Electric Exora (REEV) and UTM/Proton-developed Saga EV were seriously showcased where both prototypes were involved in the RAC Future Car Challenge 2011 from Brighton to London, and eight vehicles (five Exora REEV and three Saga EVs) were handed to the government as fleet testing vehicles (FTV). In September 2012, Parliament was told that Proton would begin selling electric vehicles by 2014. At that stage, the national car company was collaborating with UK-based Frazer-Nash Research to develop its own EV.

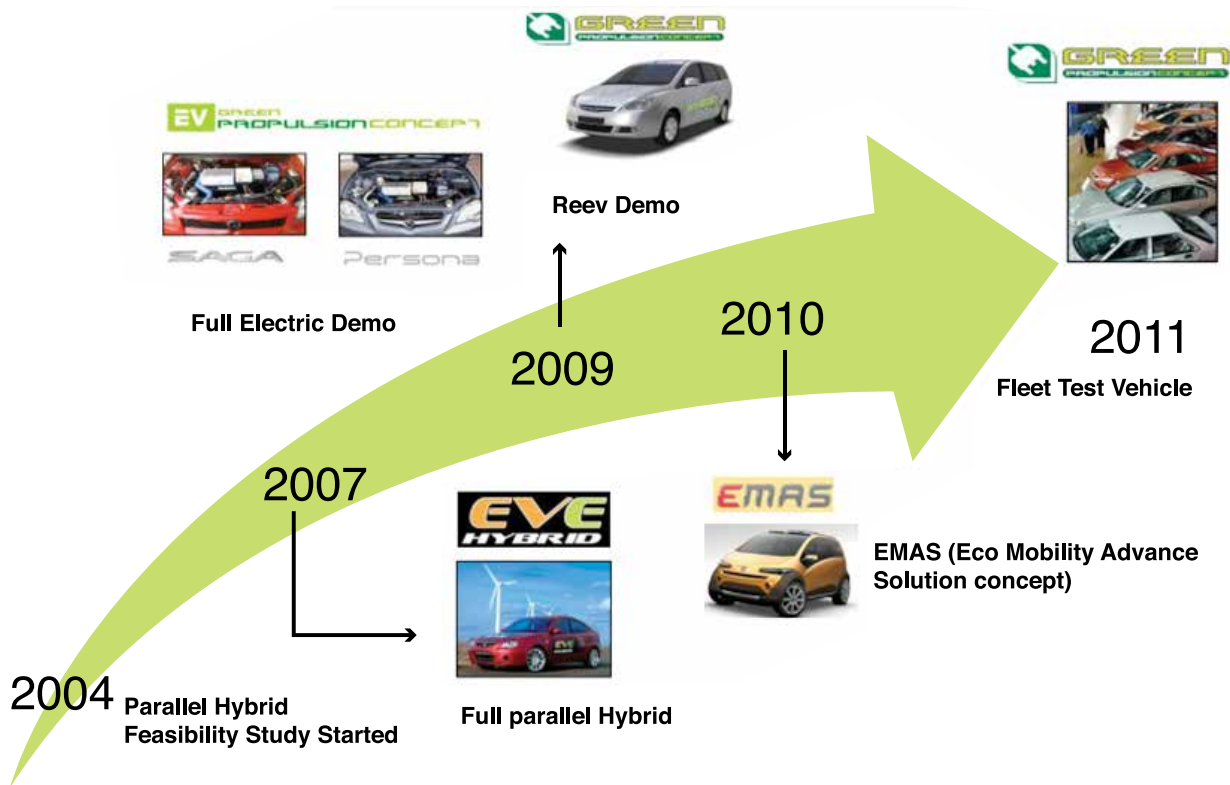


Figure 4.20 Proton HEV/EV roadmap when first announcement on the EV initiatives in conjunction with Automechanika Malaysia 2011

Source: Moving Towards Green: Opportunities for Malaysian Automotive Industry; Syed Zainal Abidin, Presentation Slides, Automechanika Malaysia 2011

The automaker was planning to introduce its first hybrid by the end of 2014, with an EV to follow by end-2015. However, the timeframe was revised again and it was believed due to unresolved technical issues. Proton is set out to roll out its Proton Iriz EV by 2017. The car was originally designed to be able to support hybrid and electric powertrains. It is reported that the prototype have an all-electric range of 240km per charge which is greater than the currently available Nissan Leaf in the market which have a range of 200km. The prototype is still a result of joint research of Proton with Frazer-Nash Research.

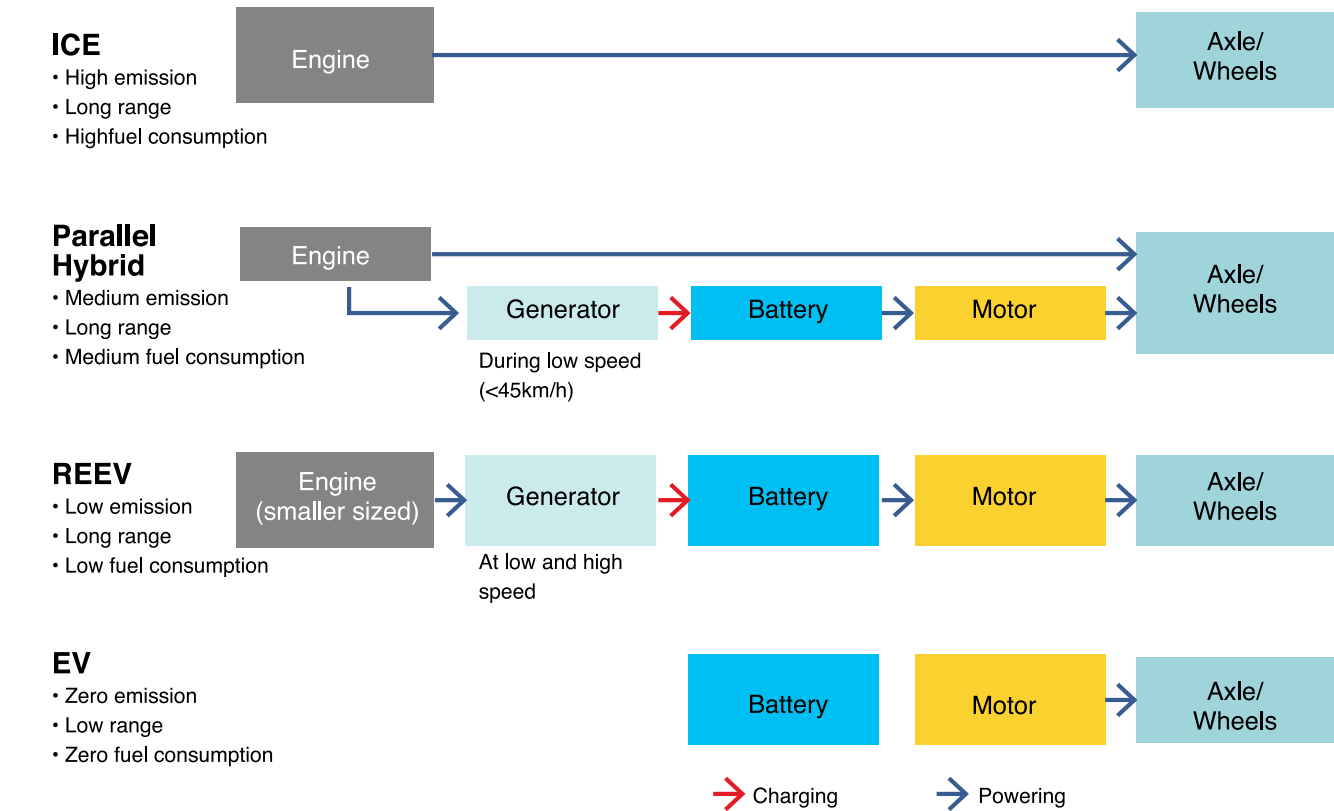


Figure 4.21 Proton HEV/EV technology classification (Abidin, 2011)

Cohesive Mobility Solution (COMOS), ASEAN'S first EV car-sharing programme was launched in Malaysia in October 2014 for the Klang Valley area. This programme provides Klang Valley residents with electric vehicle rental on an hourly basis. The whole process of rental is done conveniently through mobile phone applications where the process is automated by the system. This initiative was the first of its kind in the ASEAN region, and is a private/public partnership between CMS Consortium, MAI and GreenTech Malaysia. Among the vehicle that is used in the COMOS programme are Renault Zoe, Twizy and Nissan Leaf. Plans to expand the vehicle types

are currently underway with future plans of adding vehicles such as the BMW i3. COMOS is working closely with UTM and Celcom, where the former is given the responsibility to develop and commercialise hydrogen charging systems for EVs, and the latter will provide the payment gateway and vehicle connectivity.

Table 4.5 Available car options for COMOS

Car Model	Segment	Range	Charging Time
Renault ZOE	B	NEDC Driving Range = 209km	3 kW (single-phase 16 A Wall-Box)= 9 hours 22 kW (three-phase 32 A chargepoint) = 1 hour (80% battery charge level) 43 kW (three-phase 63 A charge point) = 30 min (80% battery charge level)
Renault Twizy	B	ECE -15 UTAC = 100km	3.5 hours (From 0% to 100%)
Nissan Leaf	B	EPA = 117km	N/A

Source: <http://paultan.org/2014/09/23/comos-launch-next-month/>

Hitherto, there are four separate initiatives from both private and public agencies on electric busses spearheaded by MAI, GreenTech Malaysia DreamEDGE Sdn Bhd. and. Sync R&D. MAI in collaboration with Bustech, Australia, ARCA Corp Sdn Bhd, AutoCRC, Austalia, and Swinburne University of Technology to develop an electric bus system as well as energy dense lithium batteries that will enable longer range per charge cycle. Trial runs of the high energy density lithium-ion batteries are currently underway and it is expected the prototype to be made available by the first quarter of 2015. Plans are in place to have the batteries manufactured locally. The first bus is planned to roll off the production line in July 2015, with trials to begin in September to be deployed initially in Putrajaya and Langkawi owing to their simple routing. ARCA Corp is said to invest RM200 million over a period of four years, with an expectation that the E-bus will be commercially available throughout the country in 2016.

GreenTech Malaysia in partnership with AMDAC (M) Sdn Bhd launched its first electric bus in August 2013 followed by a six-month pilot project to test the feasibility of electric-powered buses as a mode of

public transportation in the Klang Valley. The vehicle was used in the recent Sukma Perlis Games to ferry people to stadiums as part of efforts increase public awareness on electric mobility. The China made 29-seater 325kW BDY K9 electric bus can ferry up to 70 passengers is able to travel 250km to 300km per charge. 20 charging stations are placed throughout the bus route in Klang Valley. The bus will be making inroads as Sunway BRT has ordered 15 units and Panorama Melaka has placed an order of 40 trial busses.



Figure 4.22 IGEM-AMDAC BYD K9 e-bu.

Source: <http://paultan.org/2014/10/20/byd-k9-e-bus-amdac-set-first-deliveries/>

DreamEDGE Sdn. Bhd. is planning to produce electric busses dubbed Zero Emission Transport (ZET) eTransit for export by 2018. The vehicle is based on Japanese technology with RM 3 million investments for R&D. The bus is targeted for recreational purposes with customised features such as seat capacity. The total cost for the prototype development is about RM 1.8 million. The bus will be power by rechargeable batteries as its main power source along with auxiliary power supported by solar panel on the roof designed to complement green initiatives. Syn R&D in collaboration with Siemens, PradoTEC and SAERTEX USA is developing the Electric Bus 1 Malaysia (EB1M). As of April 2014, it is in its design verification stage and is expected to supply half of the nation's feeder bus fleet size to Prasarana/RapidKL by 2017.



Figure 4.23 DreamEDGE's ZE

Source: <http://m.utusan.com.my/bisnes/korporat/dreamedge-keluarkan-bas-elektrik-1.52382>

4.2.4 Urban Transportation Infrastructure

i) Mass Rapid Transit

The Klang Valley Mass Rapid transit is a 3 line high-capacity transport that is used to compensate and integrate the existing rail networks as well as alleviating severe traffic congestion in the KL Metropolitan area. The proposal was announced in June 2010 and is approved by the government in December 2010. The construction of the first line commenced in July 2011. The project is expected to be completed with the Sungai Buloh to Semantan Line to be fully operational by December 2016.

ii) Bus Rapid Transit

The first Bus Rapid Transit (BRT) service is expected to be available as soon as June 2015, nine months ahead of its original stipulated time. The first corridor to be implemented amongst 12 other corridors in greater KL and the Klang Valley is the KL-Klang corridor. The 34km KL-Klang BRT corridor that runs along the median lane of the Federal Highway, will start at Pasar Seni and ends at Bandar Klang. It is expected that the travel time of this service will be reduced to only 35 minutes as compared to present regular bus service that takes approximately 90 minutes. The KL-Klang BRT corridor will adopt BRT hybrid operational system, applying both direct service and trunk-and-feeder system.



Figure 4.24 BRT system

Source: <http://www.spad.gov.my/projects/2013/bus-rapid-transit-brt>

4.3 Recommendations / Action Plans

Energy diversification is evidently the ultimate approach in reducing fossil fuel and oil based energy dependency. Alternative energy sources, for solar, wind, biofuel, gaseous fuel (e.g. natural gas and hydrogen as energy carriers) are future potential energies, and are currently being developed and deployed throughout various countries around the world. In view of the drastic climate change owing to the increase in greenhouse gas emissions (GHGs), further drives the need for a clean and viable energy source.

With the transportation sector being one of the main contributors of GHGs, especially CO₂, energy efficient transportation systems are one of the means to alleviate this appalling scenario. Conventional fossil

fuel based internal combustion engine may be altered to work with biofuels both in liquid and gaseous form. Conventional engines may be further improved upon by means of hybridisation with an electric motor to provide alternating modes of propulsion. Fully electric vehicles are gaining attention owing to the depletion of fossil fuel reserves, fluctuating oil prices as well as its inherent zero emission feature. Although the price of crude oil per barrel had fallen by more than 40% since June 2014, oil prices are expected to rise towards the end of Q4 2015 due to the reduction in oil production. This uncertainty calls for effort in ensuring a more secured future that involves strategic energy diversification.

The cleanest solution for stringent emission legislation in transportation is undeniably hydrogen based fuel. The simplest form of hydrogen fuel

implementation on existing engine technologies can be carried out at minimal cost through hydrogen internal combustion engine (H2ICE). Owing to its desirable traits, countries such as The United States, Japan, Germany, European Union, South Korea and China has embarked on the race towards implementing this technology and migrating away from fossil fuel. The major barriers which hinder the widespread implementation of hydrogen economy are the mass production of the hydrogen as well as storage facilities.

Malaysia currently lags behind in the implementation of hydrogen based technology. It is unsure whether the government had properly weighed the potential of hydrogen technology as national agenda as it has never been mentioned explicitly in the previous transportation, energy or automotive policies. Nonetheless, the government has played its role in supporting hydrogen based researches by funding it through research grants. This effort is duly recognised through the establishment of Malaysia's first fuel cell institute in UKM (2006) where hydrogen fuel generation became a sub-area of research for fuelling the fuel cell. In a more recent progress, UTM had launched a dedicated center for hydrogen production, namely the Institute of Hydrogen Economy in 2009. This form of investment by the government bore fruit through the recent prototype launch of Malaysia's first fuel cell vehicle late last year by UKM.

Focus on hydrogen production must be emphasised especially through non-electrolysis means. It is envisioned that by 2020 extensive research and development takes place within both the academic as well as industrial local sphere. Once such feasible non-electrolysis process is attained/materialised,

the door for transfer of technology may be further exploited to gain the momentum required to push this technology further in Malaysia. This is crucial to drive fuel cell development from automobile manufacturers' especially local manufacturers by 2035. It is also anticipated that hydrogen production and distribution infrastructure are available at a plausible scale and locally manufactured Fuel Cell electric vehicle should be available at least LDVs by 2050.

The combination of hydrogen fuel and fuel cell as energy converter should be considered as a long term viable goal in order to achieve clean and efficient prime mover for transportation in Malaysia. The fuel cell technology must be able to serve the light, medium and heavy duty transportation sectors at acceptable fuel cell efficiency. In an attempt in fully exploiting the existing technology, national hydrogen fuel cell technology must be pushed to the next stage of commercialisation on which the prototype has demonstrated feasibility in the real world environment.

Natural gas is the main alternative fuel replacing gasoline and diesel in the world as well as in Malaysia. In the United States and North America, the widespread usage of compressed natural gas (CNG) is further expanded through the commercialisation of High Pressure Direct Injection (HPDI) technology. This technology is capable of rectifying the problems caused by undesirable low energy density properties of gas. This is further supported by the storage technology of natural gas namely the Liquefied Natural Gas (LNG). The LNG system had been tested on heavy duty vehicle and is found to be able to maximise the volume of gas stored on board. However, the cryogenic cooling system for LNGs requires additional space thus incurs additional cost and is currently

unable to serve as an economical alternative for the light duty vehicle sector.

Malaysian universities had conducted research on HPDI system and a number of HPDI technology had been patented. Previous results from these studies shows comparable engine performance to gasoline port injection. However, the researches on HPDI technology are still on-going and there are no plans stated in having HPDI CNG systems to be commercialised under the Malaysian brand. Natural gas, hydrogen and other gaseous fuel such bio-methane are shares near similar fuelling systems. Hence, natural gas and bio-methane for example are the right candidate to bridge the intermediate gap between current Malaysian scenario and fully hydrogen based economy. LNG possess the potential to replace existing fuel (bunker oil) used in maritime application. The use of LNG would significantly reduce maritime emission and GHGs production.

Biogas or bio-methane is another viable candidate for future alternative fuel due to its renewable production capability. The National Biomass Strategy 2020 that aims at maximising the exploitation of palm oil product further strengthens its feasibility. Palm oil waste can not only to produce bio-gas, but it could also produce bioethanol and bio butanol. Bioethanol and biobutanol are liquid biofuels which can replace existing gasoline and diesel fuel, whereas biogas in gaseous form is interchangeable with CNG and hydrogen due to its compatible technology architecture. Biogas in its primary form may contain various components of other gases with low methane percentage. Advanced purification of biogas will produce higher fuel quality with larger percentage of methane. The search of biogas sources with highest

methane potential number must be further pursued. Malaysia as a country with vast bio-diversity is capable of producing biogas from multiple sources such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste. In tandem with the National Biomass Strategy 2020, the application of biogas for transportation from palm oil waste must be upgraded to the commercialisation phase. Previous researches on Biogas conducted by SIRIM and other research organisations are adequate to further propel this technology for commercialisation.

It is anticipated that by 2020 a wider distribution system as well as research and development in non-fossil based fuel is expedited. It is also hoped that the distribution system network as well as the non-fossil fuel sources are expanded especially with regard to the research and development of methane purification by 2035. Furthermore, it is envisioned that biogas could replace conventional natural gas at least with respect to its application on HDVs prior to LDVs by 2050.

Energy efficient vehicles are a new segment of technology brought into Malaysia through the National Automotive Policy 2014. The definition of EEV provided by the NAP 2014 document includes alternative prime mover such as the hybrid and fully electric powertrain. We would like to propose in distinguishing EEV into two categories namely ICE based EEV and Electrified EEV. In the first proposed segment of EEV, the efficiency improvement must be based on existing engine technology. The efficiency gain for existing engine technology may be possibly gained through the use of advanced cleaner propulsion technologies such as the implementation of direct injection (DI) system, emission reduction

by 3-way catalytic converter and diesel particulate filter (DPF), as well as the improvement of existing combustion efficiencies through optimum engine control strategy which includes the adaptation of alternative fuel. Further improvement of engine efficiencies can be made possible through the vehicle weight reduction by means of light weight material (high power to weight ratio) such as boron steel which can be formed by hot press forming (HPF) as well as the reduction of vehicle aerodynamics and tyre rolling resistance. The reduction of rolling resistance can be obtained by optimising materials, shape, and inflation of tyre.

These suggestions are in tandem with the suggestions proposed by ETP 2014 as well as research progress around the globe. Furthermore, the aforementioned technologies provide the lowest cost option towards in achieving the EEV requirement. Such technologies are not far-fetched and continuous research and development by means of Industry Centre of Excellence (ICoE) at local higher education institutions should be sustained throughout the stipulated timeline. Furthermore, in order to have a more energy efficient ecosystem, an online integrated traffic management system that allows and ensure route optimisation should be regulated by 2020. This system should be a standard/compulsory feature in all vehicles.

The hybrid and full electric vehicle technology that falls under the latter proposed category of EEVs, formed a new vehicle chapter in Malaysia as of 2009. The hybrid vehicle technology provides an excellent transition from internal combustion engine paradigm towards full electrification of vehicle propulsion. The import of hybrid vehicles into the local market

must be continued to extend the transition period until Malaysia's local EV manufacturers and service providers are ready for the effective implementation of EV related technologies. Nonetheless, the withdrawal of hybrid incentives announced in the NAP 2014 has inflicted a pronounced setback for the importers as well as the end users. The Malaysian government is urged to review the fiscal incentives withdrawn in the next budget dissemination as similarly echoed by GreenTech Malaysia through its eMobility Blueprint 2015. As hybrid technologies are quite complex and beyond Malaysia's technical capability owing to the maturity state (5 to 10 years ahead) of the technology at this stage, nonetheless it is hoped that by 2035, local research and development of this technology is active and by 2050 this technology is readily available by local manufacturers.

The Malaysian government should capitalise and invest on the research as well as infrastructure development to support the full electric vehicle technology deployment as it is relatively new. Public transport may possibly replace the numbers as well as the relevancy of individual transport in the near future. Therefore, electrification of public transport appears to be important, nonetheless a cost benefit analysis with respect to the outcome of such vehicles towards the environment as a whole (well to wheel) must be conducted. It is anticipated that by 2020 Proton Iriz EV is available on the road. It is also envisioned that more electric busses as well as charging stations are erected that includes both public charging (fast charge-high amps) and home charging (slow charge-low amps) by this period. Ultimately the use of LDV (pod like) akin to park and ride to cater the general public for last mile utilisation in order to reduce congestion should be online by 2050.

A crucial step in realising the electrification of transportation is essentially the enabling technologies such as the power electronics, electric motor and energy storage system. As major EV components are imported/ outsourced from overseas, Malaysia is required to develop local EV component technologies through technology transfer or localisation. The EV components are applicable for both EV and HEV. Research and development (R&D) of such technologies should be pursued initially by conducting technology scanning and transfer. This process is vital as it will provide the transition period required prior to its local development. Continuous improvement on R&D of existing technologies that has been explored in order to shift it from its lab-scale nature to pilot scale and finally commercial scale. It is hoped that the identification of viable technology to be developed by means of technology scanning and assessment on technologies that has yet to be locally developed could be conducted by 2020. It is anticipated that knowledge transfer of the suitable technologies to be developed by 2035 by inviting multi-national EV components manufacturer to invest locally and the development and assembly of the identified technologies are available locally by 2050.

Malaysia Automotive Institute (MAI) initiative on the ICoE in collaboration with the Ministry of Education is an excellent move towards the localisation of EEV technologies. Existing automotive related ICoE such as the Miyazu-UMP ICoE on hot press forming (HPF) technology, Sapura-UMP on suspension and dynamic test system, and PHN-UMP on Tailor Welded Blank (TWB) technology are exemplars of successful cooperation made so far. The major outcome of such initiatives not only focuses on technology transfer but moreover, it benefits human capital development

with regards to advanced knowledge. The effort taken by MAI in developing lithium-ion batteries with Swinburne University of Technology should be extended, especially to local public institutions as it would further develop local expertise. MAI should also widen its reach to include the ICoE for alternative fuel generation, future fuelling technology for ICE and EV propulsion system. The inclusion of existing advanced knowledge and research institutes for transportation into the mainstream industry is essential to reduce R&D cost. The Institute of Fuel Cell and Institute of Hydrogen Economy should be given the ICoE status with sufficient monetary incentives due to its excellent track record in hydrogen and fuel cell development in this country.

Following the introduction of B5 biodiesel, the government is set to mandate the use of B7 biodiesel which increases the percentage of palm oil biodiesel in the blend to 7% in the first quarter of 2015 and is studying the prospects of B10 and B20 biodiesel programmes. However, the main contention is on whether Malaysia is capable in fulfilling the blending mandates. This is essentially due to the current main constituent of Malaysian palm oil mix which originates from the same source as the refined oil for processed food. The impending B7 and higher blending mandates will surely increase the amount of palm oil mix usage and may pose as a threat for food security.

Therefore, the most viable option in balancing the transportation energy requirements is the use of palm oil waste as biomass energy source which is used to produce biogas or bio-methane. However, pure biogas cannot be used directly in engines, owing to its corrosive nature due to the existence of hydrogen sulphide, CO₂ and water. Further purification process

is required in order to harness usable fuel (methane). The main concern on the utilisation of biogas, is in its viability for large scale production which inherently involves high cost. Local research should look into the effective generation of biogas through feedstock that possess the highest methane potential number.

In the aviation sector, most of the propulsion fuel utilises kerosene or aviation fuel. Turbo jet engine is considered as one of the most highly efficient energy converter. Nonetheless, the dependency on fossil oil reduction as a whole, will require the use of alternative fuel. The use of gaseous fuel in liquid form (for example LNG and Liquid H2) appears to be a bright option. The properties of gas eliminates the predicament arise in vaporising the fuel and mixture preparation. The technology of liquefied gaseous also

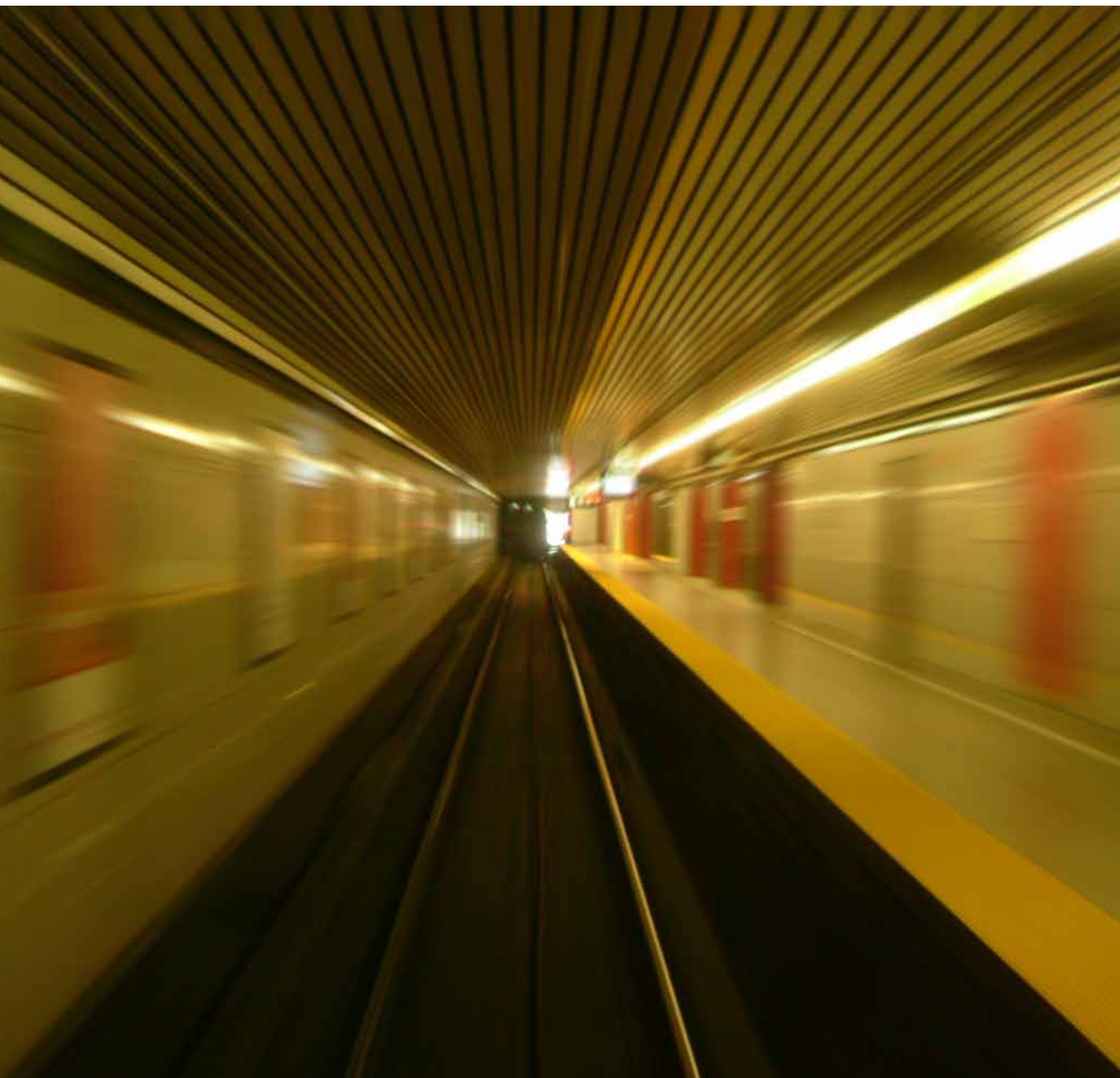
benefits the rail sector as most of railway trains are still utilising diesel engine. In recent developments, electrified aircraft (through solar with batteries or dedicated batteries) have made ways as an alternative means of propulsion system for light aircrafts. Carbon emissions at airports could be significantly reduced by aircrafts utilising hybrid electric power whilst on the ground as demonstrated by El Al. The reduction of emissions could further be reduced by electrifying ground support vehicles. The same principle could also be applied to the maritime sector at ports, as demonstrated by Port of Tanjung Pelepas which is in the process of electrifying all of its rubber tyred gantry (RTG) cranes.

The recommendations/action plans together with the expected implementation timeline are as follow:

PROPOSED RECOMMENDATIONS / ACTION PLANS	STRATEGIES		
	2020	2035	2050
Hydrogen and Fuel Cell	X	X	
R&D on hydrogen production. (non –electrolysis)			
Feasible non-electrolysis processes may be materialised, that in turn drives fuel cell development (from automobile manufacturers)			
Transfer of technology on the application vehicle		X	X
Hydrogen production and distribution infrastructure are available at a plausible scale.			
Locally manufactured Fuel Cell vehicle should be available. Application on LDV.			

Natural Gas & Bio-Methane/ Biogas Wider distribution system – to cater the storage issues. R&D in non-fossil based Expanded network, non- fossil fuel sources should be expanded R&D in methane purification Application on HDVs and further perhaps expanded to LDVs Replace conventional NG to biogas/syngas.	X X	X X	X X
Electrification of Vehicles Status Iriz.EV may take off More electric busses should be available – cater public transportation Regulating of online monitoring system as standard/ compulsory vehicle requirement Hybrid R&D Hybrid should take off Autonomous pod like on tracks (long term), crash free – safety aspects, electrified, efficient due to light weight Ultimately the use of LDV akin to park and ride to cater the general public (pod like) – last mile utilisation –reduce congestion	X X X	X	X X X

Key Enabling Technologies The identification of viable technology to be developed by means of technology scanning and assessment on technologies that has yet to be locally developed Knowledge transfer of the suitable technologies to be developed Multi-national EV components manufacturer should be invited to invest locally. Local development and assembly of the identified technologies	X		
		X	
		X	
			X
Energy Efficient Vehicles (Conventional ICE) The efficiency gain for existing engine technology may be possibly gained through the use of advanced cleaner propulsion technologies such as the implementation of direct injection (DI) system, emission reduction by 3-way catalytic converter and diesel particulate filter (DPF), as well as the improvement of existing combustion efficiencies through optimum engine control strategy which includes the adaptation of alternative fuel. To increase the number of ICOE	X	X	X
	X	X	X





Summary and Conclusion

5.1 Summary

This report has identified the various environmental impacts asserted by the transportation sector, making it clear that proper strategies are necessary to keep our nation growing without adversely affecting the nature. Based on the outcomes from two stakeholder workshops, these strategies are divided into two aspects, namely policy (Chapter 3) and technology (Chapter 4). By looking at the current policy and technology status, both from global and local perspectives, corresponding action plans have been recommended and documented in this report.

In terms of Policy, this report identified the needs to establish a Transport Master Plan that covers land, air and water transportations. The Transport Master Plan should concentrate on the concepts of transit oriented

development, supported by well-developed and accessible public transportation networks, to ensure sustainable city development. To ensure continual development and improvement of the transportation system in Malaysia, the master plan should pave way for the establishment of Transport Research Centre as well. Various push and pull factors, including incentivising and improving the efficiency of public transports, implementing road zoning or congestion charging for city areas, enforcing end of life policy for vehicles, etc., will encourage the use of public transports over private transports.

Nevertheless, it is of paramount importance to ensure that sufficient pull factors, particularly efficient and affordable public transport system, are already in place before the push factors can be introduced. From the stakeholder workshops, two important trends for future transportation systems have been identified,

namely electric vehicles (EV) and Internet of Vehicles (IoV). In light of this, this report recommends the government and automotive industry to look into these areas, and start developing suitable policies to pave way for the development of EV and IoV. In particular, the Electric Vehicle Policy needs to consider not only the electric vehicle itself, but also to take into account source of power to the end-of-life management. As the use of EVs will increase the electricity consumption, it is important to ensure sufficient infrastructure developments to support the industry. Furthermore, if this rise of electricity demand is met by building more fossil fuel based generation plants, the purpose of using EV for carbon emission reduction will be lost.

Hence, there is a need to increase electricity generation from renewable sources to accommodate for the rise in energy demand caused by EVs. Apart from these, this report recommended the implementation of vehicle taxes and incentive to encourage the use of energy efficient transport. Mandatory energy usage and fuel labelling schemes for vehicles are suggested as well, as a move to increase awareness on energy usage and energy efficiency in transportation.

In terms of Technology, this report called for the diversification of energy sources and the increase of energy efficiency in transportation sector. Natural gas, particularly compressed natural gas (CNG) and liquefied natural gas (LNG), is a potential option as a substitute to gasoline and diesel. As a more sustainable source of fuel, the use of biogas as an alternative fuel for vehicles is highly favourable. Nevertheless, further developments on the biogas, such as to increase its methane percentage and bring it to commercial level, are necessary. The

development of biodiesel, through the existing B5 and B7 biodiesel program, can be extended. However, attention is raised on the importance to ensure that the development of bio-fuel does not affect food production and food security of our nation. Through this report, the stakeholders have highlighted their interest on hydrogen based fuel and its related technology, as it is considered the cleanest solution for stringent emission legislation in transportation. The implementation of hydrogen based technology is still considered lagging in Malaysia, with activities mainly confined within universities, such as in UKM (fuel cell development), UTM (hydrogen production) and UMPEDAC from UM (power electronics converter for fuel cells). Support should be given to conduct more R&D the technology to bring it to real applications in Malaysia.

For electric vehicle technology, this report has identified the need to develop local expertise on EV components, such as power electronics, electric motors and energy storage systems, via technology transfer or localisation. The stakeholders have recognised that the MOE and MAI's initiatives on ICoE, such as Miyazu-UMP ICoE (hot press forming technology), Sapura-UMP (suspension and dynamic test system) and PHN-UMP (Tailor Welded Blank technology), are beneficial to the localisation of transportation technology. It is recommended that similar effort can be extended to Swinburne University of Technology (lithium-ion battery development), Institute of Fuel Cell from UKM (fuel cell development), UMPEDAC from University of Malaya (power electronics and energy management system), Institute of Hydrogen Economy from UTM and etc.

5.2 Conclusion

Transportation is the backbone of a nation's growth and hence demand due attention from all stakeholders. Based on the findings in this report, it is clear that transportation takes up a significant chunk of the world's as well as our nation's energy usage. Given the rate of population increase in Malaysia, it is easy to see that the energy consumed by the transportation sector is riding on a rising tide. It is thus a timely effort to sit back and review the energy usage and energy efficiency in the transportation sector, and propose corresponding strategies and mitigation plans.

It is anticipated that the transportation will evolve from the currently fossil-fuel-based transports to a mix of fossil-fuel-based and non-fossil-fuel-based transport, then eventually to full electric vehicles. Transports will also transform from being user-driven to fully autonomous and interconnected as Internet of Vehicles. Malaysia should be well prepared to these developments by adopting relevant policies and developing new technologies.

It is hoped that this report will provide a clear picture on the energy usage and energy efficiency in transportation sector, and serve as a guideline for the relevant stakeholders to act upon. As a concluding remark, it is worth noting that there will be no use for a first class policy and technology blueprint, if there they are not supported by first class implementation and monitoring actions.



[illegible]

References

Abidin, S.Z. 2011. Moving Towards Green: Opportunities for Malaysian Automotive Industry;, Presentation Slides, Automechanika Malaysia.

Bernama 2014, 'AirAsia flies relief goods, aid workers to Kota Baru and Terengganu', viewed 21 April 2015, <<http://www.themalaymailonline.com/malaysia/article/airasia-flies-for-free-relief-goods-aid-workers-to-kota-baru-and-terengganu>>.

BP, 2014. Energy Outlook 2035 [Online] available at <http://www.bp.com/content/dam/bp/pdf/Energy-economics/Energy-Outlook/Energy_Outlook_2035_booklet.pdf>. [Accessed: 20th April 2015]

Bradshaw CJA, Giam X, Sodhi NS. 2010, 'Evaluating the Relative Environmental Impact of Countries', PLoS ONE 5(5): e10440. doi: 10.1371/journal.pone.0010440

Britannica 2014, 'Kinabatangan River, Malaysia', viewed 20 April 2015, Encyclopaedia Britannica Online Database.

Chorus Motors, 2010. Aerospace. [Online] Available at <http://www.chorusmotors.gi/aerospace.php>. [Accessed on 20th April 2015].

Den Boer, LC., Schrotten, A. 2007, 'Traffic noise reduction in Europe: Health effects, social costs and technical and policy options to reduce road and rail traffic noise', Delft: CE Delft, http://www.transportenvironment.org/sites/te/files/media/2008-02_traffic_noise_ce_delft_report.pdf

E. Levi, R. Bojoi, F. Profumo, H.A. Toliyat and S. Williamson. 2007. Multiphase induction motor drives – a technology status review. IET Electric Power Application, 1(4), pp.489-516.

Energy Information Administration (EIA) 2009, Available from: <http://www.eia.doe.gov/oiaf/servicerpt/hr2454/index.html>.

European Commission, 2003. Hydrogen Energy and Fuel Cells,

European Commission. 2005, 'Questions & Answers on Aviation & Climate Change' viewed 20 April 2015, http://europa.eu/rapid/press-release_MEMO-05-341_en.htm?locale=en.

Global Transport Scenarios 2050 - GTS 2050, World Energy Council (2011)

Hyundai Elevator.2011. Hyundai Elevator – The EL Ultra high speed elevator.

IMO 2015, 'Air Pollution, Energy Efficiency and Greenhouse Gas Emissions' viewed 20 April 2015, <http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Default.aspx>

ICET - The Innovation Center for Energy and Transport (2008):Background and strategy of Chinese low carbon fuel standards and policies. Available on www.icet.org.cn ICET 2008

International Energy Agency, 2013. A Tale of Renewed Cities: A policy guide on how to transform cities by improving energy efficiency in urban transportation systems.

International Energy Agency. 2014. Energy Technology Perspectives 2014: Harnessing Electricity's Potential. Paris: IEA Publication.

Johansson, B. 1997. 'The cost of transportation – Energy and environmental impact' in Emin Tengström and Marie Thynell (eds.) SBR Session 6. Towards Sustainable Mobility: Transporting people and goods in the Baltic Region. pp. 13-18.

Jung, E., Yong, H, Sul, SK, Choi, H, Choi, Y. 2012. A Nine-Phase Permanent-Magnet Motor Drive System for an Ultrahigh-Speed Elevator. IEEE Trans. on Industry Applications, 48(3), pp.987-995.

Laws of Malaysia Act 333: Road Transport Act 1987, viewed 21 April 2015, http://www.kkr.gov.my/files/akta_subsiadiari/9.pdf

Mahalingam E., 2014. Demand for CKD hybrid cars [Online] Available at: <http://www.thestar.com.my/Business/Business-News/2014/07/28/Demand-for-CKD-hybrid-cars-Honda-and-Mercedes-models-leading-the-pack/?style=biz>. [Accessed on 18th May 2015]

Mahalingam E., 2014. Demand for CKD hybrid cars. The Star Online, 28th July 2014. [Online] Available at: <http://www.thestar.com.my/Business/Business-News/2014/07/28/Demand-for-CKD-hybrid-cars-Honda-and-Mercedes-models-leading-the-pack/?style=biz>. [Accessed on 18th May 2015]

Malaysia Automotive Institute, 2014. National Automotive Policy 2014.

MARPOL Annex VI, International Maritime Organisation (2011)

MAS 2012, 'Malaysian Airline Berhad: Environmental Report 2012', viewed 20 April 2015, <http://www.malaysiaairlines.com/content/dam/malaysia-airlines/mas/PDF/Malaysia%20Airlines%20Environmental%20Report%202012.pdf>

Merk O. 2014, 'Shipping Emissions in Ports: Discussion Paper No. 2014-20', International Transport Forum, Paris, France, viewed 21 April 2015, <http://www.internationaltransportforum.org/jtrc/DiscussionPapers/DP201420.pdf>.

MOT 2012, 'Amanat Tahun Baru 2012', viewed 20 April 2015, <http://www.mot.gov.my/my/About/Pages/Amanat%20Tahun%20Baru%202012.aspx>.

Office of The Prime Minister of Malaysia 2010, 'Government Transformation Programme: Chapter 11 - Improving Urban Public Transport', viewed 21 April 2015, <http://www.pmo.gov.my/GTP/>

Oh TH, Chua SC. 2010, 'Energy efficiency and carbon trading potential in Malaysia', Renewable & Sustainable Energy Reviews, vol. 14, no.7, pp. 2095–103.

Ong, H.C., Mahlia, T.M.I. & Masjuki, H.H., 2011. A review on emissions and mitigation strategies for road transport in Malaysia. Renewable and Sustainable Energy Reviews, 15(8), pp.3516–3522. Available at: <http://dx.doi.org/10.1016/j.rser.2011.05.006>.

Ong, H.C., Mahlia, T.M.I. & Masjuki, H.H., 2012. A review on energy pattern and policy for transportation sector in Malaysia. *Renewable and Sustainable Energy Reviews*, 16(1), pp.532–542. Available at: <http://dx.doi.org/10.1016/j.rser.2011.08.019>.

PBL Netherlands Environmental Assessment Agency 2012, 'Roads from Rio+20: Pathways to achieve global sustainability goals by 2050', The Hague: PBL Netherlands Environmental Assessment Agency.

Say, TL & Mahalingam, E 2014, 'NAP a bane for hybrid car players', *The Star Online*, 1 March, viewed 21 Apr 2015, <http://www.thestar.com.my/Business/Business-News/2014/03/01/NAP-a-bane-for-hybrid-car-players-Only-one-player-benefits-from-CKD-duty-waiver/?style=biz>

Shuhaili, AFA, Ihsan, SI, Faris, WF. 2013, 'Air Pollution Study of Vehicles Emission In High Volume Traffic: Selangor, Malaysia As A Case Study', *WSEAS Transactions on Systems*, vol. 12, no. 2, pp. 67-84.

SPAD, 2014 'Klang Valley Rail Transit Map', viewed 21 April 2015, <http://www.spad.gov.my/klang-valley-rail-transit-map>

Tee, LS. 2014. NAP a band for hybrid car players. *The Star Online*. St March 2014. [Onlin] Available at: <http://www.thestar.com.my/Business/Business-News/2014/03/01/NAP-a-bane-for-hybrid-car-players-Only-one-player-benefits-from-CKD-duty-waiver/?style=biz>[Accessed on 19th May 2015].

Tesla Motors. n.d. Motor: About the size of a watermelon, with a lot more juice. [Online] Available at: <http://my.teslamotors.com/roadster/technology/motor>. [Accessed on 20th April 2015].

World Economic Outlook 2014, IMF - International Monetary Fund (2014)

Appendix

The recommendations given in this report have been opinions of the participants from the two stakeholder workshops. The workshops were structured so that the recommendations were specific to the topics of discussions (namely Policy and Technology), rather than being stakeholder-oriented.

To ease the recommendations into executable actions by the stakeholders, the task force has disseminated the information and restructured the recommendations to be stakeholder-specific. The results are given in the following table:

STAKEHOLDERS	PROPOSED RECOMMENDATIONS / ACTION PLANS	STRATEGIES		
		2020	2035	2050
Transportation related government agencies (MOT, SPAD, JPJ, MAI, etc.)	Policy			
	• Integrated Transport Master Plan to address development of transportation system in Malaysia in a holistic manner.	x		
	• Action plans for implementing and monitoring the (existing and upcoming) policies.	x		
	• Internet of Vehicle (IoV) Policy.		x	
	• Electric Vehicle Policy.	x		
	• Malaysia should proceed with its own pace for higher emission standard, on par with Europe and USA standards.	x		
	• Continue development of biofuel as a source of energy for transportation.	x		
	• Implement mandatory energy usage and fuel efficiency labelling for vehicles. Corresponding enforcement policy should be outlined.			
	Technology			
	• Electrification of vehicles			
	- More electric busses should be available - cater public transportation.	x		
	- Regulating of online monitoring system as standard/ compulsory vehicle requirement.	x		
	- Ultimately the use of LDV akin to park and ride to cater the general public (pod like) – last mile utilisation – reduce congestion.			x
	• Energy efficient vehicles (conventional ICE)			
	- To increase the number of ICOE	x	x	x

STAKEHOLDERS	PROPOSED RECOMMENDATIONS / ACTION PLANS	STRATEGIES		
		2020	2035	2050
Finance related government agencies (MOF, MITI, EPU etc.)	Policy - Integrated Transport Master Plan to address development of transportation system in Malaysia in a holistic manner - Action plans for implementing and monitoring the (existing and upcoming) policies - Tax and incentive policy to phase out energy inefficient vehicles - Implement mandatory energy usage and fuel efficiency labelling for vehicles. Corresponding enforcement policy should be outlined.	x		
		x		
		x		
		x		
	Technology - Key enabling technologies - Knowledge transfer of the suitable technologies to be developed - Multi-national EV components manufacturer should be invited to invest locally - Energy efficient vehicles (conventional ICE) - To increase the number of ICOE	x		x
		x		
			x	
Energy related government agencies & Utility (KeTTHA, TNB, SEB, SESB, etc.)	Policy - Integrated Transport Master Plan to address development of transportation system in Malaysia in a holistic manner. - Action plans for implementing and monitoring the (existing and upcoming) policies. - Malaysia should proceed with its own pace for higher emission standard, on par with Europe and USA standards. - Continue development of biofuel as a source of energy for transportation.	x		
		x		
		x		
		x		
		x		
		x		
	Technology - Hydrogen and fuel cell - Hydrogen production and distribution infrastructure are available at a plausible scale. - Natural gas & bio-methane/ biogas - Wider distribution system – to cater storage issues - Expanded network, non-fossil fuel sources should be expanded	x		x
			x	

STAKEHOLDERS	PROPOSED RECOMMENDATIONS / ACTION PLANS	STRATEGIES		
		2020	2035	2050
Research and innovation related government agencies and universities (MOE, MOHE, MOSTI, MAI, etc.)	Policy • Integrated Transport Master Plan to address development of transportation system in Malaysia in a holistic manner – establishment of Transport Research Centre. • Internet of Vehicles (IoV) • Electric Vehicle Policy Technology • Hydrogen and fuel cell - R&D on hydrogen production - Transfer of technology on vehicle application • Natural gas & bio-methane/ biogas - R&D n non fossil based - R&D in methane purification • Electrification of vehicles - Hybrid R&D • Key enabling technologies - The identification of viable technology to be developed by means of technology scanning and assessment of technologies that has yet to be locally developed - Knowledge transfer of the suitable technologies to be developed • Energy efficient vehicles (conventional ICE) - The efficiency gain for existing engine technology may be possibly gained through the use of advanced cleaner propulsion technologies such as the implementation of direct injection (DI) system, emission reduction by 3-way catalytic converter and diesel particulate filter (DPF), as well as the improvement of existing combustion efficiencies through optimum engine control strategy which includes the adaptation of alternative fuel.	x x x x x x x	x x x x x x x	x x x x x x x

STAKEHOLDERS	PROPOSED RECOMMENDATIONS / ACTION PLANS	STRATEGIES		
		2020	2035	2050
Automotive industry (Proton, Perodua, etc)	Policy			
	• Integrated Transport Master Plan to address development of transportation system in Malaysia in a holistic manner – establishment of Transport Research Centre.	x		
	• Internet of Vehicles (IoV)		x	
	• Electric Vehicle Policy			
	Technology			
	• Hydrogen and fuel cell	x		
	- Transfer of technology on vehicle application.			
	- Hydrogen production and distribution infrastructure are available at a plausible scale.			x
	- Locally manufactured fuel cell vehicle should be available. Application on LDV.		x	
	• Natural gas & bio-methane/ biogas			x
	- Wider distribution system – to cater storage issues			
	- Expanded network, non-fossil fuel sources should be expanded			
	- Application on HDVs and further perhaps expanded to LDVs			
	- Replace conventional NG to biogas/syngas	x		
	• Electrification of vehicles			
	- Iriz EV may take off.		x	x
	- More electric busses should be available – cater public transportation.			
	- Regulating of online monitoring system as standard/ compulsory vehicle requirement.			x
	- Hybrid should take off.			
	- Autonomous pod like on track (long term), crash free – safety aspects, electrified, efficient due to light weight.	x		
	- Ultimately the use of LDV akin to park and ride to cater the general public (pod like) – last mile utilisation – reduce congestion.	x		

STAKEHOLDERS	PROPOSED RECOMMENDATIONS / ACTION PLANS	STRATEGIES		
		2020	2035	2050
	- Key enabling technologies - Knowledge transfer of the suitable technologies to be developed. - Multi-national EV components manufacturer should be invited to invest locally. - Local development and assembly of the identified technologies. - Energy efficient vehicles (conventional ICE) - To increase the number of ICOE.	x x	 x x x	x x x x x





ACADEMY OF SCIENCES MALAYSIA

Level 20, West Wing, MATRADE Tower
Jalan Sultan Haji Ahmad Shah
off Jalan Tuanku Abdul Halim
50480 Kuala Lumpur, Malaysia

Phone | +6 (03) 6203 0633
Fax | +6 (03) 6203 0634

www.akademisains.gov.my

ISBN 978-983-2915-26-3



9 789832 915263

