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LOW CARBON ECONOMY ROADMAP FOR MALAYSIA: ROLE OF THE POWER GENERATION SECTOR

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Reducing carbon intensity has been pledged by many countries at many previous UN talks. Malaysia will reduce its CO_2 intensity by up to 40% by the year 2020 conditional upon receiving the transfer of technology and adequate financing from the developed world. The objectives of this paper are to analytically review the trends in carbon emissions in the energy sector, to assess the potential reversibility of the growth of carbon emissions and carbon intensity in the energy sector through the use of renewable resources and recommend a roadmap to achieve a low carbon economy target by 2020 with implications on the development of renewable energy resources in the country. Our business-as-usual scenario shows that he rate of growth of the total CO_2 emissions is observed to be increasing at an increasing rate beginning 1990 contributed mainly from the electricity and heat production sector, the transport sector and the manufacturing industries and construction sector. The second scenario takes the pledged target as given and a schedule for CO_2 emission is developed to achieve the goal while maintaining a steady economic growth of 5-6%. In our analysis, we developed a schedule of CO_2 intensity reduction which shows that the CO_2 intensity must be reduced by 4.014% *per annum* during 2012-2020 period in order to achieve the target of 0.7415 kg per US$. We next developed schedules for total CO_2 emissions trend to be followed identifying the power generation sector to contribute under three scenarios of 0%, 5% and 6% GDP growth. The burden to the power generation sector will be lighter if the GDP grows by 6% per year. A review on existing and future energy sources for electrical power generation has revealed that Malaysia has emphasised on the development of RE focusing on harnessing energy from resources such as solar, biomass, mini-hydro, wind and tidal energy.

Keywords: Carbon intensity, Climate change, Renewable energy, CO_2 emission.

1. Introduction

Malaysia has seriously considered and integrated the environment as an important element in its planning processes, placing importance on environmental sustainability in its national policies and development plans. Serious efforts to ensure environmental sustainability in Malaysia started with the enactment of the Environment Quality Act (EQA) in 1974 which provided the legal basis for the protection and control of environmental pollution and the enhancement of environmental quality. Since then, environmental sustainability has been consistently addressed in Malaysia's development plans starting from the Third Malaysia Plan (1976-1980) up to the present Tenth Malaysia Plan (2011-2015).

Malaysia is a party to several Multilateral Environment Agreements including the United Nations Framework Convention on Climate Change (UNFCCC or the Convention) which was entered into force

on February 16, 2005. Climate change is believed to have been caused by the accumulation of greenhouse gases (GHGs) in the atmosphere due to anthropogenic activities. A Low Carbon Economy (LCE) or Low Fossil Fuel Economy (LFFE) is an alternative to minimize the output of GHG emissions, which specifically refers to carbon dioxide (CO_2), into the biosphere. Globally implemented LCE's therefore are proposed as a means to avoid catastrophic climate change, and as a precursor to the more advanced, zero-carbon society and renewable-energy economy.

On December 17, 2009 the Malaysian Prime Minister declared at the United Nations Climate Change Conference, 2009 during the 15th Conference of Parties (COP15) in Copenhagen that Malaysia will reduce its CO_2 intensity by up to 40% by the year 2020 conditional upon receiving the transfer of technology and adequate financing from the developed world. Reducing carbon intensity has been pledged by many countries at many previous UN talks. It is not about putting a cap on the absolute carbon emissions. Carbon intensity reduction leaves room for growth by allowing a limited increase of carbon emissions. There are many ways we can achieve the carbon-intensity target by 2020. With a growing economy, that may still allow emissions to rise, whereas an absolute cap would set a carbon ceiling. For example, China's current goal is to reduce emissions per dollar of economic output by 40-45% in 2020, from 2005 levels. Even China was not ready to announce a cap at the United Nations talks in Germany on June 3-14, 2013, where such a move might have spurred other nations to step up measures against global warming (Alex Morales, 2013).

The general objective of this paper is to analytically review the trends in carbon emissions in the country and recommend a roadmap to achieve a low carbon economy target by 2020 with implications on the development of renewable energy resources in the country. This study embarks on the following objectives:

1) To assess the trend of carbon emissions and carbon intensity of various sectors in the economy, led by the power generation sector
2) To develop and recommend a schedule of carbon emissions and monitor its progress up to 2020 in meeting the committed levels
3) To assess the potential reversibility of the growth of carbon emissions and carbon intensity in the energy sector through the use of renewable resources

2. CO_2 Emissions Problem

Carbon intensity is defined as carbon emission per unit of GDP. The concept ties to the economic development disparity and perceived equality. Using carbon intensity per dollar of GDP has been criticised by the World Resources Institute as this approach does not ensure absolute reductions of carbon emissions if GDP grows faster than intensity declines (Herzog, 2007). The U.S. National Environmental Trust (2002) labelled carbon intensity, "a bookkeeping trick which allows the U.S. administration to do nothing about global warming while unsafe levels of emissions continue to rise". Meeting the global greenhouse gas (GHG) emission goals currently pledged by countries under the United Nations Framework Convention on Climate Change (UNFCCC) would still leave the world some 13.7 billion tonnes of CO_2 – or 60% – above the level needed to remain on track with the 2°C goal of temperature drop in 2035. Driving down global emissions of CO_2 by at least 50% by 2050 may be necessary to avoid the most dangerous impact of global climate change (IEA, 2010). To achieve these steep emission declines while supporting continued economic growth and expanded energy access, particularly in the world's emerging economies, the world's economies must rapidly decarbonise, reducing the amount of CO_2 produced for each unit of economic activity at greater than 4% per year (IEA, 2010). Even at a national scale, achieving a 4% per year or greater rate of decarbonisation is unprecedented in recent history, according to new analysis from the Breakthrough Institute, which examines historic decarbonisation rates among developed nations in the Organization for Economic Cooperation and Development (OECD) (Jenkins, 2012). Compared to the long-term global historic 1971-2006 decarbonisation rate of 1.3% per year, only five nations achieved sustained decarbonisation rates more

than double the long-term global average: Sweden (at 3.6% per year), Ireland (at 3.2%), the UK and France (each at 2.8%), and Belgium (at 2.6%). Six other nations achieved rates between 50-100% greater than the global average rate: Germany (2.5% per year), the United States, Denmark, and Poland (each at 2.3%), Hungary and the Netherlands (at 2.0 %). In recent years, Malaysia's carbon intensity has been decreasing by 3.16% per year between 2005 and 2009 while the long-term historic 1971-2006 rate of decarbonisation for comparison was impressive at 3.53% per year according to our estimation.

The CO_2 emissions per capita in Malaysia were reported at 7.67 metric tons in 2010, up from 7.10 metric tons in 2009, according to the World Bank. However, back in 2005 the CO_2 emission per capita was 6.99 metric tons. By the year 2020, Malaysia has committed to reduce the CO_2 emission intensity by up to 40 percent in comparison to the 2005 level (Bernama Press, 2009). The CO_2 emissions intensity as measured by kg per US$ of Gross Domestic Product (GDP) for the base year of 2005 has shown a downward trend since 2005 at 1.2358 to 1.2109 in 2010. Despite an economic growth of 5-6 percent the Malaysian government is committed to reduce the CO_2 emissions intensity to 0.7415 kg per 2005 US$ of GDP in 2020. Since CO_2 intensity is measured as CO_2 per GDP, the strategy to reduce the CO_2 intensity is to increase the GDP sufficiently while maintaining the total CO_2 emissions or allowing for limited increase in total CO_2 emissions. An alternative strategy is to reduce the total CO_2 emissions. Both strategies can lead to a reduction in CO_2 intensity to achieve the target in 2020, but not necessarily the absolute quantity of carbon emissions. A schedule is developed in this paper as a benchmark to monitor the actual annual emission of CO_2 for the country up to 2020.

3. Methodology

The study is an exploratory research employing grounded theory approach in order to gather enough information to formulate a strong energy policy. Time series data from the World Bank are used to study the trend in carbon dioxide emission as well as carbon intensity in the major sectors, especially the energy sector. The GDP for Malaysia will be projected to 2020 at the growth rate of 5-6%. Using the projected GDP the carbon intensity and carbon emissions will be scheduled targeting 2020 as the terminal year when the carbon intensity will be reduced to 60% of the 2005 level (i.e. a reduction by 40% of the 2005 level). The growth rates of carbon intensity and carbon emissions will be estimated using the Accounting Growth method, i.e.

$$A_n = A_o(1+r)^n$$

where A_n is the targeted CO_2 intensity in year 2020 and A_o is the base year to be projected from 2010. Thus, r is computed as follows:

$$r = (A_n/A_o)^{1/n} - 1$$

Another method used in this analysis is the scenario approach. According to Schwartz (1996), "scenarios are tools for ordering one's perceptions about alternative future environments, and the end result might not be an accurate picture of tomorrow but can give better decisions about the future. No matter how things might actually turn out, both the analyst and the policy maker will have a scenario that resembles a given future, and that will have helped us think through both the opportunities and the consequences of that future". None of the existing policy models captures the full effects of climate change strategies. For this reason, our study uses the scenario approach for analysis.

Scenario 1 is defined as a "business-as-usual" (BAU) situation where a historical trend of the country's CO_2 emission is estimated and projected into the near future. Scenario 2 is defined as a planned schedule of CO_2 emission in meeting the targeted CO_2 intensity as pledged by the country. In both scenarios, the country's economic growth of 5% and 6% are assumed. A 5% growth in GDP is assumed as it is realistic and the country has consistently maintained growth at above this level for a long time. A 6% GDP growth is also assumed as the country has targeted this growth rate as achievable in the Vision 2020 policy. All of the required time-series data are obtained from the World Bank website (data.worldbank.org/) for the period of 1960-2012 or whenever it is the most recent.

4. Results and Analysis

Our analysis begins with a review of the trends in CO_2 emissions from the major sectors of the economy (section 4.1). Our "business-as-usual" scenario uses the estimated trend equations to forecast the time when the targeted CO_2 intensity as pledged can be achieved (section 4.2). The second scenario takes the pledged target as given and a schedule for CO_2 emission is developed to achieve the goal while maintaining a steady economic growth of 5-6% (section 4.3). Finally, our analysis focuses on the roadmap for the power generation sector (section 4.4).

4.1 CO_2 Emissions from Major Sectors

Five major sectors that emit the most CO_2 from fuel combustion are: 1) electricity and heat production, 2) transportation, 3) manufacturing industries and construction, 4) residential buildings and commercial and public services, and 4) other sectors, excluding residential buildings and commercial and public services. The first three sectors are the largest contributors to CO_2 emissions since 1970s. The increase in CO_2 emissions is very evident for the three sectors beginning 1990 while the latter two sectors remained quite stable (Fig. 1).

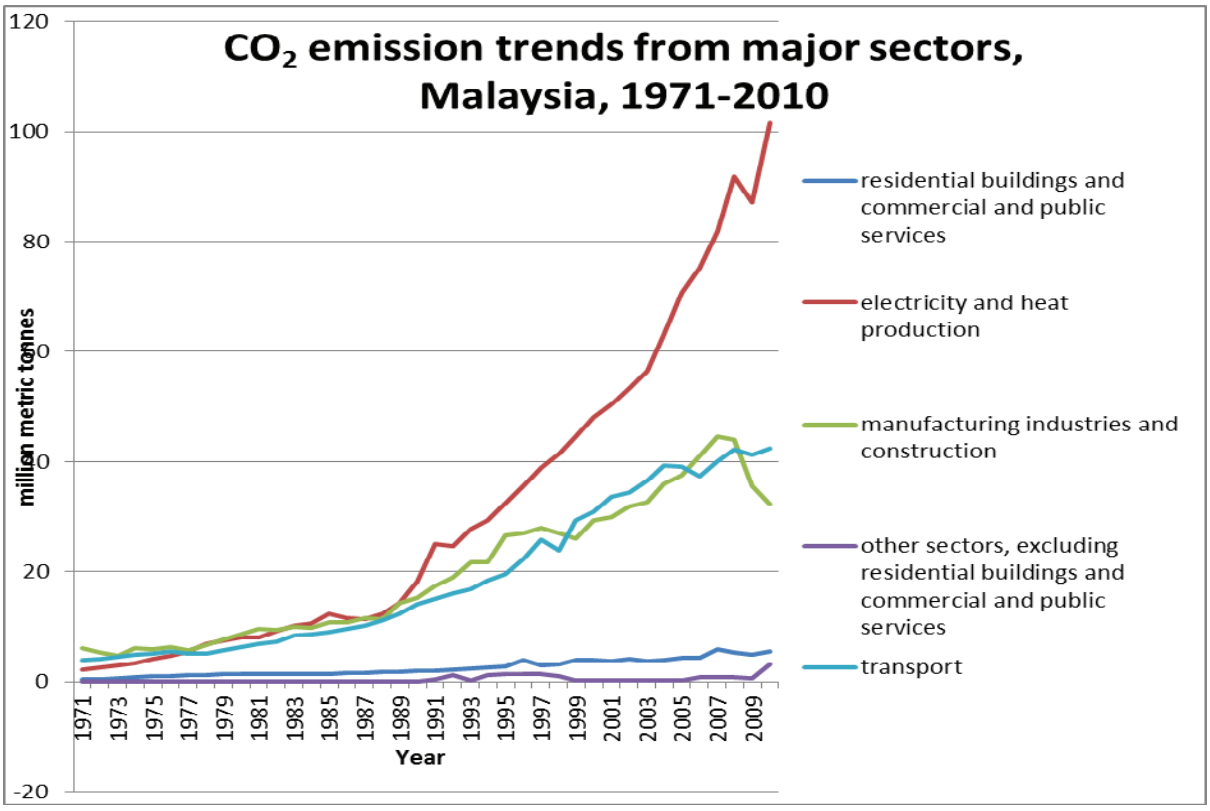


Figure 1. CO_2 emission trends from major sectors, Malaysia 1971-2010

4.1.1 *Historical Trend in CO_2 Emissions from Major Sectors*

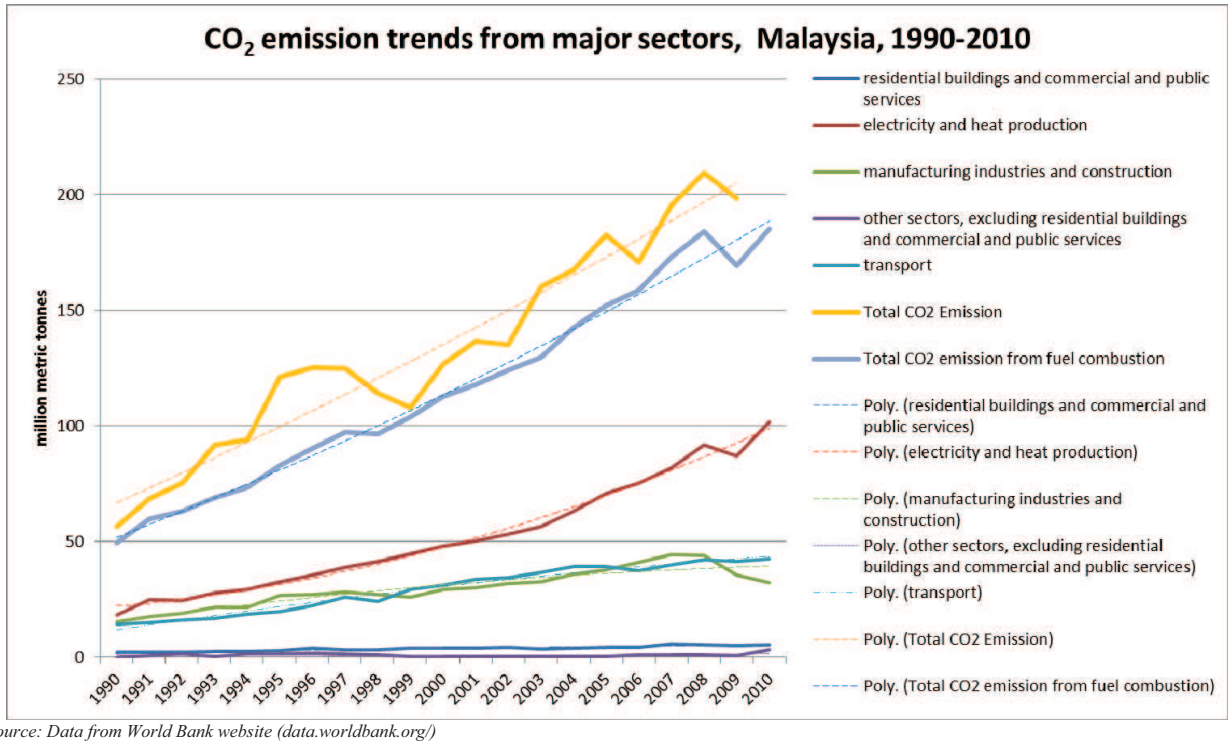
Historically, the manufacturing industries and construction sector contributed the most (48.27%) to the CO_2 emissions from fuel combustion in the country in 1971 followed by the transport sector (31.81%). The electricity and heat production sector (or the power generation sector) contributed only 16.77% of the CO_2 emissions from total fuel combustion (Table 1). This situation is reversed by 2010 where the power

generation sector is now contributing 54.94 % of the CO_2 emissions from fuel combustion growing at the rate of 11.15% annually during 1971-1990 period and 8.96% annually during 1990-2010. The transport sector remains second in its contribution to the CO_2 emissions from fuel combustion (22.94%) growing at the annual rate of 6.40% during 1971-1990 period and 5.69% during 1990-2010. The manufacturing industries and construction sector which contributed 48% in 1971 is now contributing 17.41% of the CO_2 emissions from fuel combustion in 2010. CO_2 emissions from this sector increased annually at 4.79% during 1971-1990 but slowed down to 3.79% annual growth by 2010. The residential buildings and commercial and public services sector contributed 3.15% of CO_2 emission in 1971 but had its share reduced to 2.97% in 2010 while the other sectors' contribution had increased from 0% in 1971 to 1.75% in 2010.

Table 1. CO_2 emissions by sectors, 1971-2010 (million tonnes).

Sector	1971	1980	1990	2000	2009	2010
Electricity and heat production	2.13	8.05	18.28	48.15	87.13	101.64
% of total fuel combustion	*16.77*	*33.14*	*36.83*	*42.72*	*51.42*	*54.94*
Annual growth rate		*11.15%*			*8.96%*	
Transport	4.04	6.32	14.04	30.94	41.29	42.43
% of total fuel combustion	*31.81*	*26.02*	*28.28*	*27.45*	*24.37*	*22.94*
Annual growth rate		*6.40%*			*5.69%*	
Manufacturing industries and construction	6.13	8.6	15.3	29.35	35.55	32.21
% of total fuel combustion	*48.27*	*35.41*	*30.82*	*26.04*	*20.98*	*17.41*
Annual growth rate		*4.79%*			*3.79%*	
Residential buildings and commercial and public services	0.4	1.32	2.02	3.93	4.89	5.49
% of total fuel combustion	*3.15*	*5.43*	*4.07*	*3.49*	*2.89*	*2.97*
Annual growth rate		*9.01%*			*5.13%*	
Other sectors, excluding residential buildings and commercial and public services	0	9.71E-17	0	0.33	0.58	3.23
% of total fuel combustion	*0.00*	*0.00*	*0.00*	*0.29*	*0.34*	*1.75*
Annual growth rate		*0*			*11.62%*	
CO_2 Emission from total fuel combustion	**12.7**	**24.29**	**49.64**	**112.7**	**169.44**	**185**
% of total CO_2 emissions	*76.15*	*86.76*	*87.71*	*89.02*	*85.43*	N.A.
Annual growth rate		*6.97%*			6.80%	
Others from non-fuel combustion	3.98	3.71	6.95	13.90	28.91	N.A.
Total CO_2 emissions	**16.68**	**28.00**	**56.59**	**126.60**	**198.35**	N.A.
Annual growth rate		*6.28%*			*4.42%*	

Source: Data from World Bank website (data.worldbank.org/)



Source: Data from World Bank website (data.worldbank.org/)

Figure 2. CO_2 emission trends from major sectors, Malaysia 1990-2010.

4.1.2 *Recent trends in CO_2 Emissions from Major Sectors*

The general trends in CO_2 emissions show a sharp increase in the amount of CO_2 emissions from the three major sectors beginning 1990, viz. the power generation sector, the transportation sector and the manufacturing industries and construction sector, in that order. The power generation sector alone contributed more than half of the CO_2 emissions from the total fuel combustion in 2010. A trend-line of CO_2 emissions is fitted to each sector for the period 1990-2010 (Fig. 2) and the equations including the total CO_2 emissions from fuel combustion and the total CO_2 emissions from fuel and non-fuel sources are presented in Table 2. Focus is given to the power generation sector as it is the single most important sector that has contributed to the problem of CO_2 emissions in the country and which has the vast opportunity to reduce the CO_2 emissions by utilizing renewable energy resources.

Table 2. Trend line equations for CO_2 emissions from major sectors, Malaysia 1990-2010.

Major sectors	Trend-line equation	R^2
Electricity and heat production	$y = 20.77 + 1.01x + 0.1293x^2$	0.9902
Transport	$y = 9.549 + 2.2137x - 0.0282x^2$	0.9751
Manufacturing industries and construction	$y = 13.192 + 2.0659x - 0.0392x^2$	0.8515
Residential buildings and commercial and public services	$y = 1.7695 + 0.1771x - 0.0001x^2$	0.8846
Other sectors excluding residential buildings and commercial and public services	$y = 1.0584 - 0.1095x + 0.006x^2$	0.1108
Total CO_2 emission from fuel combustion	$y = 46.339 + 5.3573x + 0.0677x^2$	0.9878
Total CO_2 emission	$y = 60.343 + 6.2704x + 0.0482x^2$	0.9381

Source: Data from World Bank website (data.worldbank.org/)

4.2 Scenario 1: Business-as-Usual Schedule of CO_2 Intensity Reduction

Our business-as-usual scenario examines the current trends of CO_2 emissions from fuel combustion by the major sectors of the economy. The rate of growth of the total CO_2 emissions is observed to be increasing at an increasing rate beginning 1990, contributed mainly from the electricity and heat production sector, the transport sector and the manufacturing industries and construction sector. Hence, any attempt to reduce the total CO_2 emissions should focus on these three sectors. The trend line equations are used to forecast the total CO_2 emissions in meeting the target reduction in CO_2 emissions intensity under 5% and 6% economic growth assumptions. With the business-as-usual scenario we determine whether the target CO_2 emissions intensity is achievable by the year 2020 as pledged.

4.2.1 *Forecasted Trends in CO_2 Emissions from Major Sectors*

The trend line equations as shown in Table 2, if plausible under the business-as-usual scenario, are used to forecast the CO_2 emissions and CO_2 intensity up to the year 2020, given the conservative 5% GDP growth. From 2012 onwards CO_2 emissions from the electricity and heat production sector (or the power generation sector) will grow at the rate of 5.79% *per annum*, (11.15% annually during 1971-1990 period and 8.96% annually during 1990-2010). The manufacturing and construction sector will see a negative growth (-0.13%) of CO_2 emissions (4.79% during 1971-1990; 3.79% during 1990-2010), while the transport sector will experience a small growth of 1.44% in the CO_2 emissions (6.40% during 1971-1990 period and 5.69% during 1990-2010). The other two sectors' contributions to CO_2 emissions are rather small and their growth rates are quite trivial. Most importantly, we might see the growth in the total CO_2 emissions of 3.42% from 2012-2020 (Table 3). Hence, given the GDP growth of 5% *per annum* the CO_2 intensity is computed for the years 2009-2020 where CO_2 intensity is defined as CO_2 emission divided by GDP in 2005 constant US$. It is expected that between 2012 to

Table 3. CO_2 emission forecast by sectors, 2012-2020 (million metric tonnes)

Year	Electricity and heat production	Manufacturing industries and construction	Transport	Residential buildings and commercial and public services	Other sectors excluding residential buildings and commercial and public services	Total CO_2 emission	GDP (billion US$) 5% (2011-2020)	CO_2 intensity (kg/US$)
	Trend line equations (million metric tonnes)							
	$y = 20.77 + 1.01x + 0.1293x^2$	$y = 13.192 + 2.0659x - 0.0392x^2$	$y = 9.549 + 2.2137x - 0.0282x^2$	$y = 1.7695 + 0.1771x - 0.0001x^2$	$y = 1.0584 - 0.1095x + 0.006x^2$	$y = 60.343 + 6.2704x + 0.0482x^2$		
2012	112.400	39.971	45.546	5.7899	1.714	230.083	235.5413698	0.9768275
2013	119.487	40.194	46.435	5.9623	1.886	238.621	247.3184383	0.9648336
2014	126.833	40.340	47.267	6.1345	2.071	247.256	259.6843602	0.9521386
2015	134.437	40.406	48.042	6.3065	2.267	255.986	272.6685782	0.9388186
2016	142.300	40.395	48.761	6.4783	2.476	264.814	286.3020071	0.9249452
2017	150.421	40.304	49.424	6.6499	2.696	273.737	300.6171074	0.9105852
2018	158.801	40.136	50.030	6.8213	2.929	282.758	315.6479628	0.8958011
2019	167.440	39.889	50.580	6.9925	3.173	291.875	331.4303610	0.8806514
2020	176.337	39.564	51.074	7.1635	3.430	301.088	348.0018790	0.8651904
Growth Rate (%) 2012-2020	5.79	-0.13	1.44	2.70	9.06	3.42	5.0	-1.51

Source: Data from World Bank website (data.worldbank.org/)

2020 the CO_2 intensity will decrease by 1.51% *per annum* to reach 0.865 kg per 2005 constant US$ which is short of the target of 0.7415 kg per 2005 constant US$. Thus, under the business-as-usual scenario and given the GDP growth rate of 5% *per annum* Malaysia will fail to meet its target of CO_2 intensity reduction.

4.2.2 *CO_2 Intensity Target Forecast*

Using the total CO_2 emission trend equation the CO_2 intensity schedule is computed under the GDP growth scenarios of 5% and 6% and results are presented in Table 4. As noted earlier with a GDP growth rate of 5% Malaysia will fail to reach the target CO_2 intensity by 2020. With the negative growth rate of 1.51% *per annum* the country will only achieve its target of CO_2 intensity of 0.7415 kg per 2005 constant US$ sometime between 2027 and 2028 if the country's GDP grows at 5%. However, if the economy grows at 6% per annum it will achieve the said target of CO_2 intensity between 2022 and 2023. Then, the CO_2 intensity will be reduced by 2.43% *per annum*. Perhaps, Malaysia can achieve the target CO_2 intensity under the business-as-usual scenario by 2020 if the GDP grows at 6.9%. Otherwise, Malaysia can still achieve its target CO_2 intensity by 2020 by reducing the growth in the total CO_2 emissions below 3.42% which can come quite easily from slowing down the growth of CO_2 emissions from the power generation sector, which under the business-as-usual scenario is growing at the rate of 5.79% (refer Table 3).

Table 4. CO_2 intensity forecast, 2012-2025 (CO_2 in million metric tonnes).

CO_2 intensity forecast, (business-as-usual), 2012-2028 with GDP growth at 5% and 6% per annum					
Year	**Total CO_2 emission**	**@ 5% GDP growth**		**@6% GDP growth**	
	$y = 60.343 + 6.2704x + 0.0482x^2$	**GDP** (billion US$)	**CO_2 intensity (kg/US$)**	**GDP** (billion US$)	**CO_2 intensity (kg/US$)**
2012	230.083	235.5413698	0.9768275	237.7846209	0.9676121
2013	238.621	247.3184383	0.9648336	252.0516982	0.9467151
2014	247.256	259.6843602	0.9521386	267.1748001	0.9254447
2015	255.986	272.6685782	0.9388186	283.2052881	0.9038897
2016	264.814	286.3020071	0.9249452	300.1976053	0.8821312
2017	273.737	300.6171074	0.9105852	318.2094617	0.8602431
2018	282.758	315.6479628	0.8958011	337.3020294	0.8382926
2019	291.875	331.4303610	0.8806514	357.5401511	0.8163408
2020	301.088	348.0018790	0.8651904	378.9925602	0.7944427
2021	310.398	365.4019730	0.8494690	401.7321138	0.7726484
2022	319.804	383.6720716	0.8335345	425.8360406	0.7510025
2023	329.307	402.8556752	0.8174309	451.3862031	0.7295453
2024	338.906	422.9984589	0.8011989		
2025	348.602	444.1483819	0.7848765		
2026	358.394	466.3558010	0.7684987		
2027	368.283	489.673591	0.7520980		
2028	378.268	514.1572706	0.7357043		
Growth Rate (%) 2012-2025	3.42	5.0	- 1.51	6.0	-2.43

Source: Data from World Bank website (data.worldbank.org/)

4.3 Scenario 2: Planned Schedule of CO_2 Intensity Reduction

In 2005 Malaysia's population was 25.8 million and with CO_2 emission recorded at 177372.79 kt., the CO_2 emission per capita was 6.99 tonnes. Malaysia's GDP was US$143.533 billion and thus, the CO_2 intensity in 2005 as measured by kg per US$ of GDP for the base year of 2005 was recorded at 1.23576 kg per US$. On December 17, 2009 the Malaysian Prime Minister declared at the United Nations Climate Change Conference, 2009 during the 15th Conference of Parties (COP15) in Copenhagen that Malaysia will reduce its CO_2 intensity by up to 40% by the year 2020. Hence, a target is set for the CO_2 emissions to be reduced to 0.7415 kg per 2005 constant US$ by 2020. Since CO_2 intensity is measured as CO_2 divided by GDP the strategy is to increase the GDP sufficiently so as to reduce the CO_2 intensity while maintaining the total CO_2 emissions or allowing for limited increase in CO_2 emissions towards 2020. An alternative strategy is to reduce the total CO_2 emissions while maintaining GDP constant or by allowing a limited increase in the GDP. Both strategies can lead to a reduction in CO_2 intensity to achieve the target in 2020.

In our analysis, we developed schedules to reduce CO_2 intensity using growth accounting procedure. Our schedule of CO_2 intensity reduction shows that the CO_2 intensity must be reduced by 4.01% *per annum* during 2012-2020 period in order to achieve the target of 0.7415 kg per US$. We next developed schedules for total CO_2 emissions trend to be followed without identifying which sectors to contribute under three scenarios of 0%, 5% and 6% GDP growth (Table 5).

4.3.1 *Total CO_2 Emissions with Zero GDP Growth*

Although unlikely, a scenario of 0% GDP growth is chosen as a benchmark to show how much and at what rate the total CO_2 emissions must be reduced to achieve the target CO_2 intensity. With zero GDP growth, obviously the total CO_2 emissions must be reduced. However, the rate of reduction is seemingly large at 4.01% per year, but considering the current trend from business-as-usual scenario where the total CO_2 emissions will be increasing at the rate of 3.42% during 2012-2020 period (see Table 3), the task of reversing the rate of growth in the total CO_2 emission is not easy.

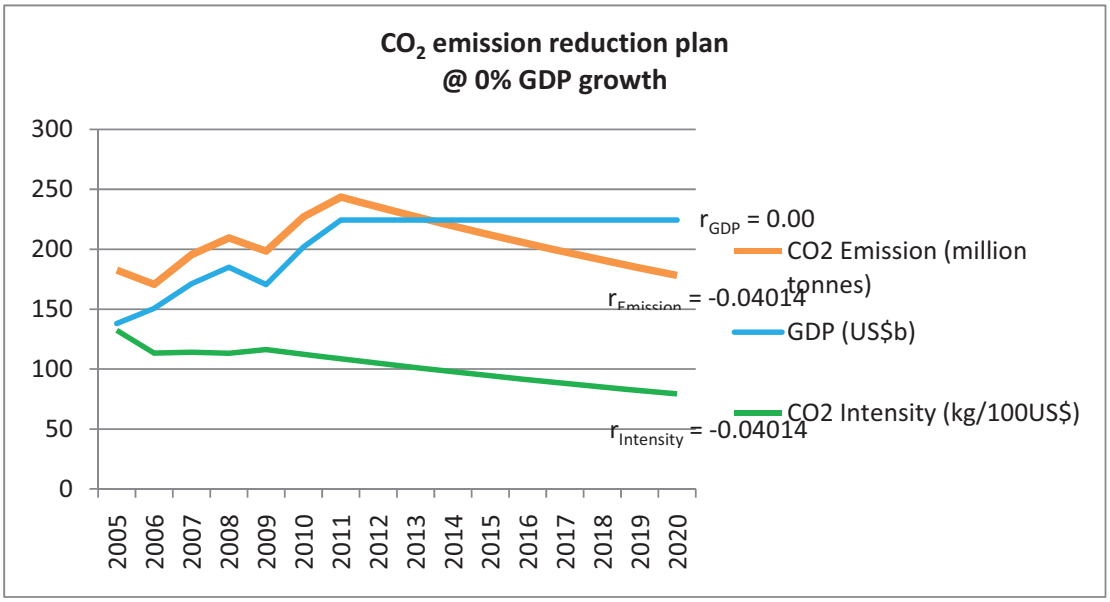


Figure 4. Total CO_2 emission reduction plan @ 0% GDP growth.

Table 5. Planned schedule of CO_2 intensity reduction, 2012-2020 .

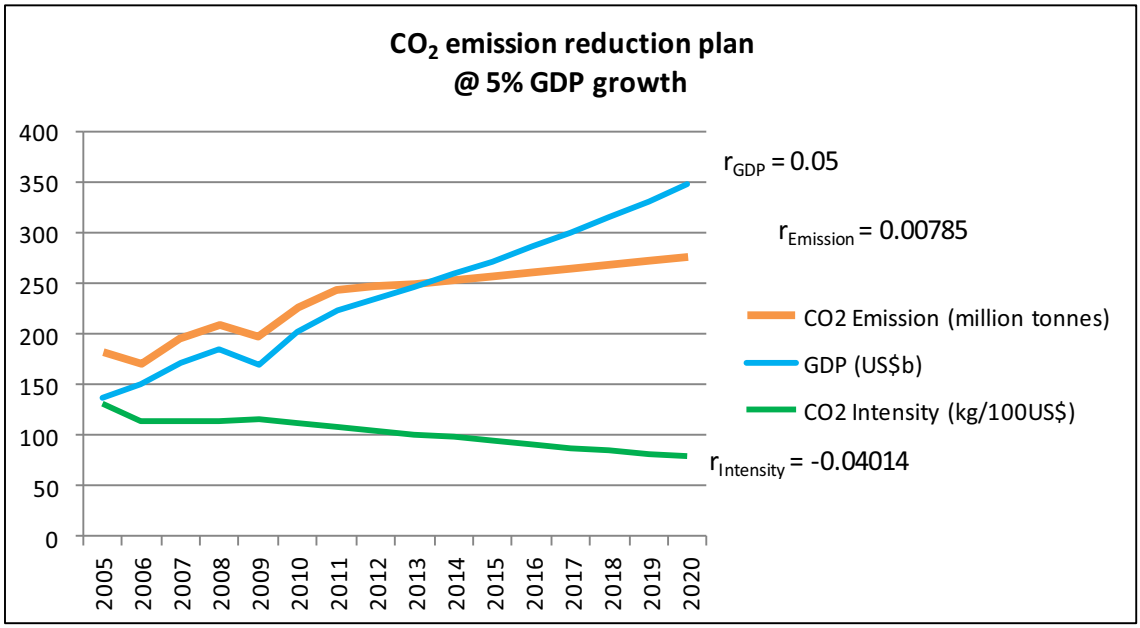
Planned schedule of CO_2 intensity reduction 2012-2020 (with variable GDP growth, 2012-2020)							
Year	**CO_2 intensity**	**GDP growth at 0%**		**GDP growth at 5%**		**GDP growth at 6%**	
		GDP	**Total CO_2**	**GDP**	**Total CO_2**	**GDP**	**Total CO_2**
	kg/US$	2005 US$	kt	2005 US$	kt	2005 US$	kt
2005	1.235761825	1.43533E+11	177372.790	1.43533E+11	177372.790	1.43533E+11	177372.790
2006	1.133058915	1.50608E+11	170647.512	1.50608E+11	170647.512	1.50608E+11	170647.512
2007	1.141373327	1.71268E+11	195480.436	1.71268E+11	195480.436	1.71268E+11	195480.436
2008	1.131603322	1.85025E+11	209374.699	1.85025E+11	209374.699	1.85025E+11	209374.699
2009	1.163617734	1.70458E+11	198348.030	1.70458E+11	198348.030	1.70458E+11	198348.030
2010	1.116907514	2.01880E+11	225480.736	2.01880E+11	225480.736	2.01880E+11	225480.736
2011	1.072072347	2.24325E+11	240492.752	2.24325E+11	240492.752	2.24325E+11	240492.752
2012	1.029036964	2.24325E+11	230838.834	2.35541E+11	242380.776	2.37785E+11	244689.164
2013	0.987729117	2.24325E+11	221572.447	2.47318E+11	244283.623	2.52052E+11	248958.801
2014	0.94807946	2.24325E+11	212678.033	2.59684E+11	246201.408	2.67175E+11	253302.940
2015	0.910021429	2.24325E+11	204140.661	2.72669E+11	248134.249	2.83205E+11	257722.881
2016	0.873491132	2.24325E+11	195945.998	2.86302E+11	250082.264	3.00198E+11	262219.946
2017	0.838427243	2.24325E+11	188080.287	3.00617E+11	252045.573	3.18209E+11	266795.482
2018	0.804770897	2.24325E+11	180530.323	3.15648E+11	254024.294	3.37302E+11	271450.857
2019	0.772465592	2.24325E+11	173283.432	3.31430E+11	256018.550	3.57540E+11	276187.465
2020	0.741457095	2.24325E+11	166327.447	3.48002E+11	258028.462	3.78993E+11	281006.723
Growth rate (%), 2012-2020	-4.014	0.00	-4.014	5.00	0.785	6.00	1.745

Source: Data from World Bank website (data.worldbank.org/)

4.3.2 *Total CO_2 Emissions with 5% GDP Growth*

A scenario of 5% GDP growth is real and highly certain to be achieved by Malaysia in each normal year. The schedule of CO_2 emissions shows that CO_2 emissions can keep on increasing but at a slower rate of 0.785*% per annum* compared to the business-as-usual rate of 3.42%, provided that the economy grows at 5% *per annum*. By 2020 the CO_2 emissions can reach 258.028 million tonnes while the GDP grows to US$348.002b at 2005 constant US$. Then, the CO_2 emissions intensity will be 0.7415 kg per US$ which is the target level committed.

Figure 5. Total CO_2 emission reduction plan @ 5% GDP growth.



4.3.3 *Total CO_2 Emissions with 6% GDP Growth*

A scenario of 6% GDP growth is achievable by Malaysia over many normal years and is the intended growth that will uplift the country to achieve a developed status by 2020. If this is plausible, the CO_2 emissions can still be allowed to increase by 1.745% *per annum* and the target CO_2 emissions intensity of 0.7415 kg per US$ can still be achieved by 2020. At that time, the CO_2 emissions will be 281 million tonnes and the GDP will be US$378.993b at 2005 constant US$.

4.4 Carbon Emissions Roadmap for the Power Generation Sector

Efforts must be taken to reduce the growth rate of CO_2 emissions from the power generation sector as it is the sector which is increasing at a very high growth rate of 5.79% if left to its business-as-usual trend for the period 2012-2020 (see Table 3). To compound the problem of total CO_2 emissions the power generation sector alone contributes almost 55% of the total CO_2 emissions from total fuel combustion in 2010 while the fuel combustion represents 85% of the total CO_2 emissions in the country in 2009 (see Table 1).

4.4.1 *Carbon intensity Reduction from Power Generation Sector*

Reduction in the carbon intensity can be achieved through an increase in GDP while allowing for a limited increase in the total carbon emissions. In this section we simulate the role of the power

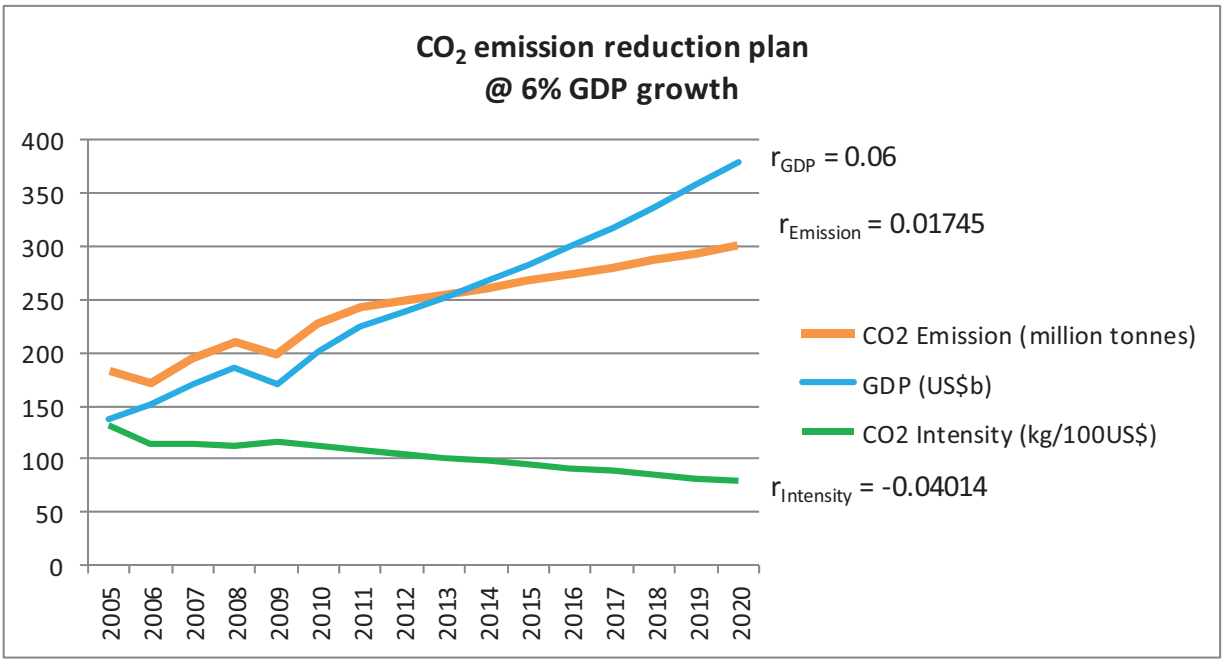


Fig. 6: Total CO_2 emission reduction plan @ 6% GDP growth

generation sector in reducing the total carbon intensity while allowing the other sectors to continue with their trend, i.e. business-as-usual. The carbon intensity schedule is developed to achieve the target pledged by 2020. Thus, the carbon intensity will be decreasing at the rate of 4.01% per year while the carbon emissions from other sectors are allowed to increase by 0.73% per year. The allowable carbon emissions schedule for the power generation sector is then developed under 5% and 6% plausible GDP growth rates. The results are displayed in Table 6.

With 5% GDP growth per year, to achieve the target carbon intensity of 0.7415 kg per US$, the total allowable carbon emissions will reach 258 million tonnes, i.e. an annual increase of 0.785% from 2012 to 2020. Thus, with all other sectors' carbon emissions increasing by 0.73% under the business-as-usual scenario, the power generation sector is allowed to increase its total carbon emissions to 133.278 million tonnes for an increase by 0.785% per year beginning 2012. The power generation sector will have a daunting task to reduce its carbon emissions growth rate from 5.79% per year under the business-as-usual scenario to just 0.84% annually from 2012 to 2020.

The burden to the power generation sector will be lighter if the GDP grows by 6% per year. With this growth rate the total carbon emissions will be allowed to increase by 1.745% annually from 2012 to 281 million tonnes in 2020. And, under business-as-usual for all other sectors, the power generation sector will be allowed to increase its carbon emissions to 156.256 million tonnes by 2020 or an increase by 2.62% over the 2012 to 2020 period compared to the 5.79% increase under the business-as-usual scenario. Reduction in the rate of growth of carbon emissions from the power generation sector is imperative and can be implemented through initiatives to increase the use of renewable energy resources.

4.4.2 *Utilization of Renewable Energy Resources*

Malaysia's efforts to reduce carbon emissions may come from the vast potential in renewable energy (RE) resources. Energy-related CO_2 emissions represent approximately 85.4% of total Malaysian CO_2 emissions in 2009. As such, trends in energy-related CO_2 emissions have a significant impact on trends in the total CO_2 emissions. Thus, reduction in the total CO_2 emissions should focus on developing RE resources.

Table 6. Power generation sector CO_2 emissions plan (million tonnes).

Power generation sector CO_2 emissions plan (million tonnes)								
Year	**CO_2 Intensity**	**Other sectors (BAU) CO_2 emissions**	**GDP @5% growth**			**GDP @6% growth**		
			GDP	**Total CO_2 emission**	**Power Generation sector CO_2 emission**	**GDP**	**Total CO_2 emission**	**Energy sector CO_2 emission**
	kg/US$	million t	US$b	million t	million t	US$b	million t	million t
2005	1.235761825	106.573	143.533	177.372790	70.80000	137.953	177.372790	70.80000
2006	1.133058915	95.448	150.608	170.647512	75.20000	150.608	170.647512	75.20000
2007	1.141373327	113.720	171.268	195.480436	81.76000	171.268	195.480436	81.76000
2008	1.131603322	117.625	185.025	209.374699	91.75000	185.025	209.374699	91.75000
2009	1.163617734	111.218	170.458	198.348030	87.13000	170.458	198.348030	87.13000
2010	1.116907514	114.296	201.880	225.480736	111.185032	201.880	225.480736	111.185032
2011	1.072072347	116.071	224.325	240.492752	124.422056	224.325	240.492752	124.422056
2012	1.029036964	117.684	235.541	242.380776	124.697200	237.785	244.689164	127.005588
2013	0.987729117	119.134	247.318	244.283623	125.149279	252.052	248.958801	129.824457
2014	0.94807946	120.423	259.684	246.201408	125.778408	267.175	253.302940	132.879940
2015	0.910021429	121.550	272.669	248.134249	126.584705	283.205	257.722881	136.173337
2016	0.873491132	122.514	286.302	250.082264	127.568288	300.198	262.219946	139.705970
2017	0.838427243	123.316	300.617	252.045573	128.729277	318.209	266.795482	143.479186
2018	0.804770897	123.957	315.648	254.024294	130.067790	337.302	271.450857	147.494353
2019	0.772465592	124.435	331.430	256.018550	131.583950	357.540	276.187465	151.752865
2020	0.741457095	124.751	348.002	258.028462	133.277878	378.993	281.006723	156.256139
Growth rate	-0.0401	0.007316	0.05	0.00785	0.00835	0.06	0.01745	0.02625

Malaysia is one of the few ASEAN countries (Philippines, Indonesia, Thailand and Vietnam) which are blessed with most of the types of RE sources. The implementation of various policies and programs by the government has increased the awareness of the importance of the role of RE in a sustainable energy system (Rahim and Liwan, 2012). Apart from that, close cooperation within the countries in this region can also further promote the use of RE in order to fulfil the demands of energy worldwide. In general, the demand pattern for biomass as one of the RE sources is expected to increase steadily. Malaysia has great potential in biomass utilization as renewable resources. The major portion of this demand will come from the existing natural forest and planned plantations. However, the government has plans to maintain or increase the contribution of RE following the introduction of the Five Energy Policy where RE is expected to feature prominently in the country. This will mean that biomass sources and bio-diesel will play an important role in the national energy balance. In Malaysia, skyrocketing palm oil prices are crucial in efforts to promote bio-diesel fuel. Government officials say that unless world oil prices increase higher than $82 a barrel, or plants achieve economies of scale, or palm oil prices receded they do not see bio-diesel plants to begin operation.

4.4.3 *Renewable Energy Policy in the Power Generation Sector*

With energy-related CO_2 representing the majority of global GHG emissions, the fight against climate change has become a defining factor for energy policy-making throughout the world – but the implications are daunting. The Malaysian government has established energy policy to address issues of energy production, distribution, and consumption. Under the National Energy Policy launched in 1979, three principal energy objectives, which are instrumental in guiding the future energy sector development, were established, namely: the Supply, Utilization and Environmental Objectives. The National Energy Policy has been subjected to a number of revisions in tandem with the development and the ever changing scenarios. The Department of Electricity and Gas Supply acts as the regulator while other players in the energy sector include energy supply and service companies, research and development institutions and consumers. Petroliam Nasional Berhad and Tenaga Nasional Berhad are the major players in Malaysia's energy sector. Three government agencies and one non-government organization (NGO) are actively involved in formulation of policies: Energy Commission, Ministry of Energy, Green Technology and Water, Malaysia Energy Centre and Centre for Environment, Technology and Development Malaysia. Hence, with the energy policy moving towards increasing the utilization of RE the prospect of carbon intensity deceleration can be achieved earlier than expected through reduction in the total CO_2 emissions rather than through increasing GDP.

Despite those initiatives the current utilization of RE resources in the electrical power generation is far below its market potential. Efforts need to be strengthened to develop a comprehensive approach in RE development by formulating and implementing a coherent national RE policy framework, policy instruments as well as financial tools and mechanisms (Shamsuddin, 2012). A review on existing and future energy sources for electrical power generation has revealed that Malaysia is in the midst of implementing a number of initiatives with regard to policy review, research and development (R&D) and applications in this area. Emphasis has been given to the development of RE focusing on harnessing energy from resources such as solar, biomass, mini-hydro, wind and tidal energy (Ali, Daut and Taib, 2012). The use of RE plays an ever increasing role in meeting the requirements of Malaysia's energy security and the effects of climate change due to the greenhouse gases emission.

4.4.4 *Renewable Energy Initiatives*

The development and utilization of renewable energy policy is intensified in Malaysia with the implementation of Small Renewable Energy Power (SREP) projects. The terms and conditions of the

Renewable Energy Power Purchase Agreement (REPPA) as well as issues related to project viability such as long-term fuel supply security and financing will be reviewed. The Clean Development Mechanism (CDM) will also be utilized to provide support for the implementation of the SREP projects. RE projects utilizing municipal waste will also be promoted (Ninth Malaysia Plan, 2006-2010).

The Ministry of Energy, Green Technology and Water was established on April 9, 2009 following the cabinet reshuffle and restructuring in March replacing the Ministry of Energy, Water and Communications (MEWC) which was established on March 27, 2004 to replace the earlier Ministry of Energy, Communications and Multimedia (http://www.ktak.gov.my). The Ministry coordinates R&D activities of the various energy-related research centres. New sources of energy such as solar and wind will be developed with emphasis on utilizing cost-effective technology as well as strengthening capacity building. In addition, activities under the roadmap on solar, hydrogen and fuel cells such as technology development and knowledge sharing will be implemented while financing mechanisms will be explored. Initiatives to enhance local capabilities in the development of indigenous RE-based technologies as new sources of growth are also being supported.

The development of bio-fuel using palm oil as a renewable source of energy is intensified during the 9th Malaysia Plan period. The introduction of a National Bio-fuel Policy (interchangeably known as the National Bio-diesel Policy) on August 10 2005 is primarily aimed at reducing the country's fuel import bill, promoting further the demand for palm oil which will be the primary commodity for bio-fuel production (alongside regular diesel), as well as to shore up the price of palm oil especially during periods of low export demand. Bio-diesel which is a blend of 5% palm olein and 95% petroleum diesel has already commenced operation in 2006 (http://my-biodisel.org/). During the initial phase, the blended diesel was utilized by vehicles of selected Government agencies.

Malaysia has approved 75 bio-diesel manufacturing projects which would annually consume about 8 million tonnes of palm oil a year and officials believed the country has already produced one million tonnes of bio-diesel in 2007. The Malaysian Palm Oil Board (MPOB) and Golden Hope Plantations are partnering to build a biodiesel plant in Labu in Negeri Sembilan—the first in the country. MPOB is investing RM 40 million. The plant produces 5,000 tonnes (approximately 36.5 thousand barrels or 1.15 million gallons) of biodiesel a month. Sime Darby Biodiesel Sdn Bhd is responsible for the production of palm biodiesel in Malaysia and its distribution overseas (http://www.biofuelsdigest.com/). Two plants in Selangor, are currently placed under its purview, one in Carey Island and another in Teluk Panglima Garang. The plant in Carey Island has an annual capacity of 60,000 tonnes while the one in Teluk Panglima Garang has an annual capacity of 30,000 tonnes.

4.4.5 *Renewable Energy Performance*

Electricity generation from renewable resources displaces the generation of power from conventional fossil fuels. The generation of RE therefore reduces the overall greenhouse gas emissions from the fossil fuel power stations. In 2008 the government established a schedule of carbon avoidance outcome for the country from the RE projects through its policy and action plan (Table 7). Based on the incremental renewable energy mix and the share of RE capacity the annual CO_2 avoidance is expected to increase to some 7 million tonnes by 2020. However, a review on the policy and action plan in 2010 revealed that by 2020 the RE projects can yield even higher CO_2 avoidance of about 7.8 million tonnes by 2020 (Table 8). The initiatives undertaken in Malaysia to ensure the success of RE projects are expected to yield cumulatively 42 million tonnes of CO_2 to be reduced from power generation by 2020. The amount is expected to further increase by 2030, to 145 million tonnes of CO_2 (Hashim, 2011).

Table 7. RE Policy Planned Outcome.

Year ending	Cumulative total RE (MW)	Share of RE capacity	Annual RE generation (GWh)	RE mix	Annual CO_2 avoidance (tonne)
2011	217	1%	1,228	1%	773,325
2015	975	6%	5,374	5%	3,385,406
2020	2,065	10%	11,227	9%	7,073,199
2030	3,484	13%	16,512	10%	10,402,484
2050	11,544	34%	25,579	13%	16,114,871

Source: Ministry of Energy, Water and Communication (2008). National renewable energy policy and action plan. Kuala Lumpur: Ministry of Energy, Water and Communication; 2008.

Table 8. National RE policy 2010 outcome.

Year ending	Cumulative total RE (MW)	Share of RE capacity	Annual RE generation (GWh)	RE mix	Annual CO2 avoidance (tonne)
2011	219	1%	1230	1%	848,493
2015	985	6%	5385	5%	3,715,415
2020	2080	11%	11,246	9%	7,759,474
2030	4000	17%	17,232	12%	11,889,887
2050	21,370	73%	44,208	24%	30,503,589

Source: Ministry of Energy, Water and Communication (2008). National renewable energy policy and action plan. Kuala Lumpur: Ministry of Energy, Water and Communication; 2010.

5. Conclusion

World energy consumption doubled between 1971 and now, bringing about a massive increase in carbon emissions. If things continue as they have, the planet will be well on its way to warming six degrees Celsius by 2100. That would mean life-threatening sea level rise, extreme heat waves, extreme storms, extreme droughts, massive collapses in land and marine-based food supplies, and the list goes on. If we are going to get below two degrees of warming the world carbon intensity will have to be cut by 5.7% from its 2010 levels by 2020, and by over 60% by 2050.

Malaysia has pledged to reduce its carbon dioxide emission up to 40 percent by the year 2020 compared to the 2005 levels subject to assistance from developed countries. The Prime Minister said that the cut was conditional on receiving the transfer of technology and adequate financing from the developed world. Malaysia's carbon intensity has been decreasing by 3.16% *per annum* between 2005 and 2009 but this rate is insufficient to reach the target reduction by 2020. Malaysia has to step up efforts to reduce the carbon intensity by 4.01% annually from 2012 to 2020 in our analysis in order to achieve the target by 2020. This can be done by reducing the annual growth rate of total carbon emissions from 3.42% to 1.75% if the GDP grows at 6% annually or to 0.79% if the economy grows at 5% per year.

The power generation sector can contribute to the reduction in the carbon intensity by reducing the annual rate of growth of its carbon emissions from 5.79% to 0.835% if the economy grows by 5% per year or to 2.625% if the economy grows at 6% per year under the business-as-usual scenario. This can be achieved if the sector intensifies its utilization of renewable energy resources to its fullest potential.

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