ENERGY CONSUMPTION AND CARBON DIOXIDE EMISSION CONSIDERATIONS IN THE URBAN PLANNING PROCESS IN MALAYSIA

Wee-Kean Fong[1]
Civil Engineer, CTI Engineering International Co., Ltd., Japan

Hiroshi Matsumoto
Professor, Department of Architecture and Civil Engineering,
Toyohashi University of Technology, Japan

Chin-Siong Ho
Professor, Faculty of Built Environment,
Universiti Teknologi Malaysia, Malaysia

Yu-Fat Lun
Researcher, Department of Architecture and Building Science,
Tohoku University, Japan

Abstract

It is now recognized that this planet and the mankind are under serious threat of global warming, thus immediate actions are required to fight against it. Among of the most important measures are to reduce energy consumptions and carbon dioxide emissions. The objectives of this study are thus to examine the current situation of energy conservation and carbon dioxide emission in Malaysia, and their considerations in the spatial planning process. While many countries have recognized the importance of the role of urban planning in energy conservation and reduction of carbon dioxide emissions, spatial planning framework in Malaysia is still lacking in this aspect. Although there are some spatial planning policies indirectly favor energy conservation, there is still no measure that directly emphasizes on promoting energy conservation and capping carbon dioxide emissions. Energy and carbon dioxide issues should thus be taken as one of the core parts in the urban planning process. While achieving the desired socio-economic developments, it is necessary to create a low energy consumptions and low carbon sustainable society.

Keywords: Global warming, Energy consumption, Carbon dioxide emission, Urban planning, Malaysia

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[1]fong@ctii.co.jp

INTRODUCTION

The world is facing the challenge of global warming and climate change issues. The anthropogenic driver of climate change is the increasing concentration of greenhouse gases (GHG) in the atmosphere. Carbon dioxide (CO_2) is the most important anthropogenic GHG, and the global increases in CO_2 concentration are due primarily to fossil fuel use and land use change (IPCC, 2007).

The most significant increase of energy consumptions and CO_2 emissions is taking place in cities, where rapidly expanding populations enjoy higher living standards and material affluence (Fong et al., 2007a & 2007b; IGES, 2004). Thus, dealing with the issues of energy consumptions and CO_2 emissions, it is necessary to focus on urban sector, and urban planning is hence playing an important role in combating global warming, or at a smaller scale, mitigating the urban heat island (UHI) phenomenon.

One of the key principles in urban planning is to achieve 'sustainable development'. The most well-known definition of sustainable development that accepted by the United Nations (UN) is 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. In achieving sustainable development, there are many aspects should be taken into consideration. The Division for Sustainable Development under the UN Department of Economic and Social Affairs has listed down the fields within the scope of sustainable development, and 'climate change' and 'energy' are among the main focuses (UN, 2007). Hence, it is necessary to take the climate change and energy issues as one of the main considerations in the urban planning process. However, studies showed that population and economic growth are the major driving forces behind increasing energy consumption and CO_2 emissions (Fong et al., 2007a; IGES, 2004). So, it would be a big challenge to maintain high quality of life in the cities while ensuring low energy consumptions and CO_2 emissions.

Recent years, due to increasing concerns on global warming issues that closely associated with CO_2 emissions, the concept of 'low carbon city' is currently gaining popularity among the urban planners and city governments. Planning of low carbon cities involves creation of low carbon society (LCS) by promoting low carbon emissions. The increases of CO_2 concentration are due primarily to fossil fuel use and land use change. Hence, urban planning through land use planning and planning control can play a vital role in implementing the idea of low carbon city, particularly during the formulation of development plans (Ho and Fong, 2007).

In the Malaysia context, due to recent thriving and prosperous in economy, urban population is expanding rapidly. Although this can bring about many conveniences on job opportunities, education and quality of life etc, it also implies that the risk of degradation of environmental quality will arise from human activities. It is thus vital for the city government to lay down policies to regulate the urban activities with the final aim of achieving sustainable development.

This study examines the current situation of energy conservation in, and reduction of CO_2 emission from Malaysia, a developing country that experiencing rapid economic transformation, industrialization and population expansion, with particular emphasis on city context energy consumptions and CO_2 emissions. The study also investigates the current considerations of energy consumptions and CO_2 emissions in the spatial planning process in this country. This paper provides a guide for further consideration in incorporating energy and CO_2 issues as the core part of urban planning process, in achieving sustainable development based on the concept of low carbon city.

GLOBAL WARMING, CARBON DIOXIDE EMISSIONS AND ENERGY CONSUMPTIONS

Global Warming and Climate Change

The issues of global warming and climate change have become a subject of intense interest all over the world since the last decade. Warming of the climate system is now evidenced from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.

In the Climate Change 2007 report (IPCC, 2007), the Intergovernmental Panel on Climate Change (IPCC) reported that eleven of the last twelve years (1995-2006) rank among the 12 warmest years in the instrumental record of global surface temperature since 1850, and the total temperature increase from 1850–1899 to 2001–2005 is about 0.76°C. It is predicted a rise in the average global surface temperature of about 2°C between 1990 and 2100 (IPCC, 2004).

The same report also revealed that, as a result of global warming, mountain glaciers and snow cover have declined and contributed to sea level rise. Global average sea level rose at an average rate of 1.8 mm per year over the period of 1961 to 2003. The rate was faster over 1993 to 2003, which was about 3.1 mm per year.

Also, at continental, regional, and ocean basin scales, numerous long-term changes in climate have been observed. These include changes in Arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones. Average Arctic temperatures increased at almost twice of the global average rate in the past 100 years. Satellite data since 1978 showed that annual average Arctic sea ice extent has shrunk by 2.7% per decade, with larger decreases in summer i.e. 7.4% per decade.

In term of precipitation, long-term observation from 1900 to 2005 showed significant increase in precipitation in eastern parts of North and South America, northern Europe and northern and central Asia, while drying has been observed in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. More intense and longer droughts have been observed over wider areas since the 1970s, particularly in the tropics and subtropics. Increased drying linked with higher temperatures and decreased precipitation has contributed to changes in drought. It was also reported that increase of intense tropical cyclone activity in the North Atlantic since 1970 is correlated with increases of tropical sea surface temperatures. In Malaysia, it is evidenced by more frequent and more serious floods, and serious floods have occurred in some regions that were not prone to flood until recent years, such as Johor and Sarawak.

Global Warming and Carbon Dioxide Emissions

Human activities are influencing the environment. Human activities, in particular those involving combustion of fossil fuels and biomass burning, produce GHG that affects the composition of the atmosphere and lead to the depletion of the stratospheric ozone layer. Land use change due to urbanization and forestry and agricultural activities is also affecting the physical and biological properties of the earth surface and subsequently affecting the regional and global climate (IPCC, 2001).

The increase in GHG concentrations in the atmosphere affects processes and feedbacks in the climate system. Qualitatively, an increase of atmospheric GHG concentrations will lead to an average increase of the temperature of the surface-troposphere system. In this respect, CO_2 is the most important anthropogenic GHG. Increased CO_2 emissions from fossil fuel use is certain to be the dominant influence on the trends in atmospheric CO_2 concentration that eventually resulted in rising global temperatures and sea level (IPCC, 2005).

CO_2 is the GHG that has the largest contribution from human activities (IPCC, 2005). The global atmospheric concentration of CO_2 has increased from a pre-industrial value of about 280 ppm to 379 ppm in 2005. The atmospheric concentration of CO_2 in 2005 exceeded by far the natural range over the last 650,000 years (180 to 300 ppm) as determined from ice cores. The annual CO_2 concentration growth rate was larger during the last 10 years (1995–2005 average: 1.9 ppm per year), than it has been since the beginning of continuous direct atmospheric measurements (1960–2005 average: 1.4 ppm per year) although there is year-to-year variability in growth rates. (IPCC, 2007)

Carbon Dioxide Emissions and Energy Use

CO_2 is the most abundant anthropogenic (human-caused) GHG in the atmosphere. Emissions of CO_2 arise from a number of sources, mainly fossil fuel combustion in the power generation, industrial, residential and transportation sectors. It is released into the atmosphere mainly by the combustion of fossil fuels such as coal, oil or natural gas, and renewable fuels like biomass (IPCC, 2005).

According to the International Energy Outlook 2006 (cf. Figure 1), world CO_2 emissions from the consumption of fossil fuels is expected to grow at an average rate of 2.1% per year from 2003 to 2030. The world CO_2 emission from the consumption of fossil fuels is predicted to increase from about 25,000 billion metric tons in 2003, to more than 40,000 billion metric tons by 2030.

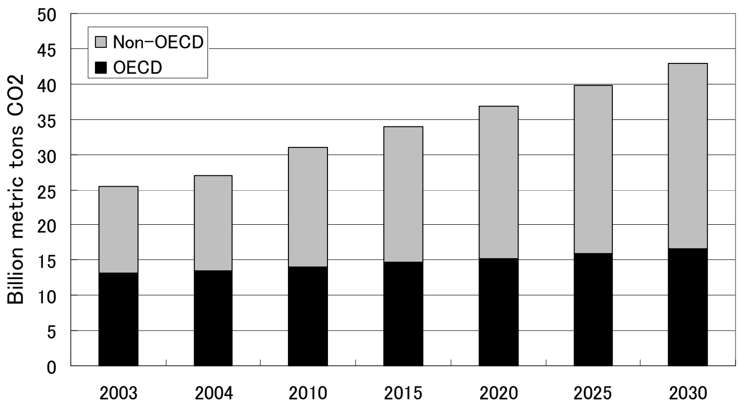

Figure 1: World energy-related CO_2 emissions by region, 1990-2030 (EIA, 2007)

The relative contributions of different fossil fuels to total energy-related CO_2 emissions have changed over time as shown in Figure 2. Increasing trend of CO_2 emissions is observed for all fuel types and they are projected to further increase steadily over the projection period up to 2030. However, for the case of emissions from petroleum and other liquids that made up the largest proportion (42%) of world total emissions in 1990, was overtaken by coal since 2005. By 2030, it is projected that coal and liquids (petroleum and other liquids) will each be contributing 43% and 36% of the world total emissions. The increasing share of coal is reflective of its important role in the energy mix of non-OECD countries, especially China and India (EIA, 2007). Also, similar trend is seen in Malaysia. In 1990, China and India combined was 13% of world emissions, but by 2004 that share had risen to 22%, largely because of a strong increase in coal use in these two countries. This trend is projected to continue, and by 2030 CO_2 emissions from China and India combined are projected to account for 31% of total world emissions, with China alone responsible for 26% of the world total.

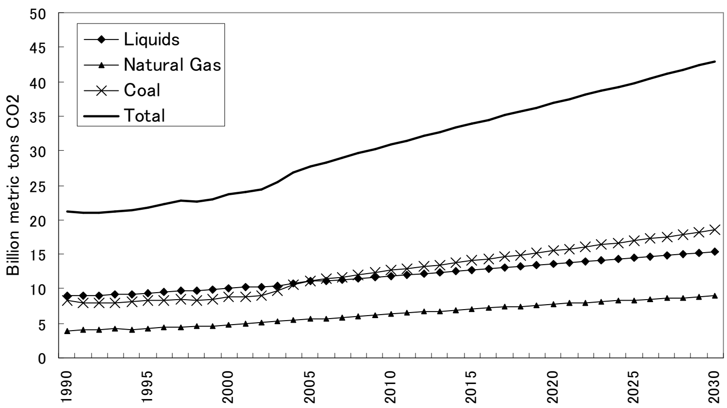

Figure 2: World energy-related CO_2 emissions by fuel type, 1990-2030 (EIA, 2007)

GLOBAL AND MALAYSIAN CARBON DIOXIDE EMSSION AND ENERGY CONSUMPTION TRENDS

Carbon Dioxide Emissions

Figure 1 above reveals that world CO_2 emissions is at an increase trend. Every country contributes different amounts of CO_2 to the atmosphere. From the figure, it can be seen that the growth rate of CO_2 emissions from non-OECD countries is higher than the OECD countries. 2004 marked the first time in history that energy-related CO_2 emissions from the non-OECD countries exceeded those from the OECD countries. Furthermore, because the projected average annual increase in emissions from 2004 to 2030 in the non-OECD countries (2.6%) is more than three times the increase projected for the OECD countries (0.8%), CO_2 emissions from the non-OECD countries in 2030, at 26.2

billion metric tons, are projected to exceed those from the OECD countries by 57%.

Table 1 shows the regional shares of CO_2 emissions against the world total emissions. In line with Figure 1, the share of OECD countries dropped from 65.9% in 1973 to 47.6% in 2005. Increases of share are seen in most of the other regions, including Asia, Latin America, Africa and Middle East. Among these regions, Asia has the most significant increase, including China, the share of CO_2 emissions from Asia escalated from 8.7% in 1973 to 28.3% in 2005. The rapid increase of CO_2 emissions from these non-OECD developing countries are mainly due to the development and industrialization over the last decades. Malaysia is also experiencing rapid economic transformation from agricultural based economy to industrial based economy since the last few decades. If comparing with the data shown in Figure 2, it can be seen that the rapid increase of CO_2 emissions from non-OECD developing countries is very closely related to the increased usage of coal as energy source. Coal is not only the most carbon-intensive fossil fuels, but is also the fastest growing energy source. The increasing share of coal is reflective of its important role in the energy mix of non-OECD countries, especially China and India. In 1990, China and India combined for 13% of world emissions, but by 2004 that share had risen to 22%, which largely because of a strong increase in coal use in these two countries (EIA, 2007).

Table 1: Regional shares of CO_2 emission, 1973 and 2005

Region/Country	Shares against world total CO_2 emissions	
	1973	2005
OECD	65.9%	47.6%
Non-OECD Europe	1.7%	1.0%
Former USSR	14.4%	8.5%
Asia (excluding China)	3.0%	9.5%
Latin America	2.7%	3.5%
Africa	1.9%	3.1%
Middle East	1.0%	4.6%
China	5.7%	18.8%
Bunkers	3.7%	3.4%
World total, mil. metric tons	*15,661*	*27,136*

Notes:

1. World includes international aviation and international marine bunkers, which are shown together as Bunkers.
2. CO_2 emissions are from fuel combustion only.

Source: IEA, 2007.

Table 1 revealed that increase of CO_2 emissions in Asia is very significant over the past decades due to rapid economic growth and industrialization. Malaysia, as part of Asia, is also experiencing rapid economic and population growth, and expected to achieve the status of developed nation by 2020 as envisaged under the Vision 2020 (EPU, 2001). The gross domestic product (GDP) growth of Malaysia was 7.0% during the last decade of the past century (1990-2000), and despite the Asian economic downturn in the late 1990's, the GDP growth rate was still maintained at 4.5% over the period of 2001-2005 (EPU, 2001 & 2006). In term of population, Malaysian population has grown from 10.3 millions in 1970 to 27.6 millions in 2007, more than 260% growth over the 37-year period.

Table 2 presents the population, GDP and CO_2 emissions of Malaysia in comparison with the world and selected regions and countries. Due to rapid economic growth and industrialization, CO_2 emission of Malaysia is relatively high compared to the world average and other Southeast Asian countries. In term of per capita emission, it is 5.45 metric tons for Malaysia, much higher than the world and Asian (excluding China) average figures of 4.22 metric tons and 1.25 metric tons respectively. Although the value is lower than the developed countries, it ranked number three in Southeast Asia, after Brunei and Singapore.

In term of total CO_2 emission, the figure for Malaysia is slightly high compared to the other developing Southeast Asian countries, which is the third highest after Indonesia and Thailand. Although the total emission for Malaysia is only about 40% of Indonesia and 64% of Thailand, the per capita emission of Malaysia is about 3.5 and 1.6 times of the values of Indonesia and Thailand respectively.

For the intensity of CO_2 emission (CO_2/GDP), although the figure for Malaysia (1.23 kgCO_2/2000$) is quite high compared to the world average (0.75 kgCO_2/2000$) and most of the developed countries (0.24-0.67 kgCO_2/2000$), it is similar to the Asian average (excluding China) and much lower than Vietnam, Indonesia and Thailand in Southeast Asia. In this respect, it can be seen that emission intensities of the developing countries are generally higher than the developed countries. Besides the factor of energy efficiency, as mentioned above, it could also be attributed to the more intensive usage of coal as energy source.

Table 2: CO_2 emissions of the world and the selected regions and countries, 2005

Region/country	Population, million	GDP, billion 2000$	CO_2 emissions, million metric tons	CO_2/capita metric ton	CO_2/GDP, kgCO_2/ 2000$
World	6,432	36,281	27,136	4.22	0.75
World regions:					
OECD	1,172	28,394	12,910	11.02	0.45
Non-OECD Europe	54	152	263	4.87	1.73
Former USSR	285	525	2,303	8.08	4.39
Asia (excl. China)	2,080	1,974	2,591	1.25	1.31
Latin America	449	1,620	938	2.09	0.58
Africa	894	731	835	0.93	1.14
Middle East	187	786	1,238	6.62	1.58
China	1,311	2,098	5,101	3.89	2.43
G8 countries:					
Canada	32.27	822.39	548.59	17.00	0.67
France	62.70	1,430.13	388.38	6.19	0.27
Germany	82.46	1,961.79	813.48	9.87	0.41
Italy	58.53	1,132.83	454.00	7.76	0.40
Japan	127.76	4,994.13	1,214.19	9.50	0.24
Russia	143.11	349.85	1,543.76	10.79	4.41
United Kingdom	60.22	1,626.78	529.89	8.80	0.33
United States	296.68	10,995.80	5,816.96	19.61	0.53
Southeast Asia:					
Brunei	0.37	4.85	5.09	13.76	1.05
Cambodia	13.64	5.66	3.71	0.27	0.66
Indonesia	220.56	207.74	340.98	1.55	1.64
Malaysia	**25.35**	**112.46**	**138.04**	**5.45**	**1.23**
Myanmar	50.52	15.20	11.02	0.22	0.73
Philippines	83.05	93.73	76.42	0.92	0.82
Singapore	4.34	112.22	43.10	9.93	0.38
Thailand	64.23	157.07	214.29	3.34	1.36
Vietnam	83.12	44.75	80.36	0.97	1.80

Source: IEA, 2007

One important issue regarding the database for CO_2 emissions in Malaysia is the inconsistency of data. For example, as shown in the above Table 2, the International Energy Agency reported that CO_2 emissions in Malaysia in 2005 was 5.45 metric tons per capita, whereas the United Nations revealed a value of 6.2 metric tons per capita for year 2002, and on the other hand, the World Resources Institute published a value of 5.4 metric tons per capita for year 2000 (IEA, 2007; UNEP, 2007; WRI, 2007). The questions are not only the consistency of the volume of emissions but also the base year of those data.

For the database on CO_2 emissions in Malaysia, the most reliable data is deemed to be the inventory developed by the Malaysia National Steering

Committee on Climate Change, which was established subsequent to the signing of the Kyoto Protocol. The national GHG inventory was established during the preparation of the Initial National Communication (INC) for the UNFCCC, which was based on the 1994 database. After the Cabinet of Malaysia had reviewed and approved the draft, the NC was launched on 18 July 2000 and submitted to the UNFCCC Secretariat on 22 August 2000 (MOSTE, 2000). Table 3 shows the emissions of the three main GHGs in 1994 on a sectoral basis. In order to provide an overall assessment, the various GHG emissions are also expressed as the equivalent of CO_2 emissions.

Table 3: Summary of Malaysia national GHG emissions and removal, 1994

Categories	CO_2		CH_4		N_2O		CO_2 equivalent (Gg)
	Gg	%	Gg	%	Gg	%	
Energy	84,415	86.7	635	28.5	0.350	86.4	97,852
Industrial process	4,973	5.1	-	-	-	-	4,973
Agriculture	-	-	329	14.8	0.0054	13.3	6,925
Waste	318	0.3	1,267	56.8	-	-	26,925
Land use change	7,636	7.8	0.13	0.006	0.001	0.3	7,639
Total (emission)	97,342	100.0	2,231	100.0	0.405	100.0	144,314
Net total (after subtracting sink)	28,625	-	-	-	-	-	75,597

Note: Total CO_2 emissions from international bunker is 785.55Gg, which has already been subtracted from the total CO_2 emissions in energy sector.
Source: MOSTE, 2000

Table 4 (INC column) shows the CO_2 emissions from final energy use (excluding electricity) by economy sector: transportation (49%), industries (41%), residential and commercial activities (7%), and agriculture (3%). It is noted that the final CO_2 emission totaling 43,768 Gg from final energy use (excluding electricity) as shown in Table 4 is very much less than the emission of 84,415 Gg estimated from primary energy supply as shown in Table 3. The latter assumed that all types of fuel are consumed for energy transformation and final use. The difference between the primary energy supply and energy demand (final use) figures could be attributed to, among others, transformation to secondary supply of energy, losses incurred during transformation and transmission, and statistical discrepancies. (MOSTE, 2000)

Table 4: CO_2 emissions from fuel combustion in Malaysia based on total final use, 1994

Source of data	INC		NC2		Increase
Year	1994		2000		
Sectors	CO_2 emissions (Gg)	Shares	CO_2 emissions (Gg)	Shares	
Residential & commercial	3,014	7%	3,947	3%	933 (24%)
Industrial	18,083	41%	28,855	22%	10,772 (37%)
Transportation	21,375	49%	41,008	31%	19,633 (48%)
Agriculture	1,296	3%	917	1%	-379 (-41%)
Energy industries and others	n/a	-	56,019	43%	-
Total	43,768	100%	130,746	100%	-

n/a: not available
Note: In the INC, energy industries was excluded from the CO_2 emission calculation.
Source: INC: MOSTE, 2000; NC2: Azman et al., 2006.

Subsequent to the NC that based on the database of 1994, as an update of the first NC, the preparation of the Second NC (NC2) with the base year of 2000 was commissioned recently and scheduled to be launched in 2009. Table 4 presents the preliminary results on the CO_2 emissions from energy use in comparison with the INC data. The breakdown of CO_2 emissions by sector shows that it is dominated by transportation (31%), energy industries (28%) (within the category of 'energy industries and others'), and manufacturing industries (22%). Comparing the data between 1994 and 2000 (excluding energy industries) revealed a significant increase of 53% in CO_2 emissions from energy use. Within these six years, CO_2 emissions had increased from 43,768 Gg to 93,621 Gg. However, it must be noted that sectoral energy use under the 1996 IPCC Guidelines have been refined, hence a direct comparison between these two years is rather complicated.

From the above, it can be seen that the national data on CO_2 emissions is rather complete although there are some variations between different sources of data. However, literature review revealed that there is complete absence of local level CO_2 emission data in Malaysia. In view of the fact that the main source of CO_2 emissions is from the urban sector (to be explained in further detail in the latter sections), there is an urgent need to establish the local level (city level) CO_2 emission data in Malaysia, especially for the major cities such as Kuala Lumpur (or Klang Valley) and Johor Bahru (or the Iskandar Development Region).

Energy Consumptions

Despite high oil prices, world economic growth is expected to continue with strong growth, driving the robust increase in world energy use. The total world consumption of marketed energy is expected to increase from about 421 quadrillion British thermal units (Btu) in 2003 to 722 quadrillion Btu in 2030 (71% increase) (cf. Table 4).

Table 4: World marketed energy consumption by country grouping, 2003-2030

Region	Energy consumption, quadrillion Btu						% p.a.
	2003	2010	2015	2020	2025	2030	
OECD	**234.3**	**256.1**	**269.9**	**281.6**	**294.5**	**308.8**	**1.0**
North America	118.3	131.4	139.9	148.4	157.0	166.2	1.3
Europe	78.9	84.4	87.2	88.7	91.3	94.5	0.7
Asia	37.1	40.3	42.8	44.4	46.1	48.0	1.0
Non-OECD	**186.4**	**253.6**	**293.5**	**331.5**	**371.0**	**412.8**	**3.0**
Europe & Eurasia	48.5	56.5	62.8	68.7	74.0	79.0	1.8
Asia	83.1	126.2	149.4	172.8	197.1	223.6	3.7
Middle East	19.6	25.0	28.2	31.2	34.3	37.7	2.4
Africa	13.3	17.7	20.5	22.3	24.3	26.8	2.6
Central & South America	21.9	28.2	32.5	36.5	41.2	45.7	2.8
Total World	**420.7**	**509.7**	**563.4**	**613.0**	**665.4**	**721.6**	**2.0**

Note: Totals may not equal sum of components due to independent rounding
Source: IEA, 2007

When comparing the energy consumption of developed and developing countries, from Table 4, it can be seen that the growth rate in energy consumption for the non-OECD countries, including Malaysia, accounts for three-fourths of the increase in world energy use. Non-OECD energy use is expected to surpass OECD energy use by year 2015. In 2030, total energy demand in non-OECD countries will exceed that in the OECD countries by 34%. During this projection period, the average growth rate of energy consumption in the non-OECD countries is triple of the OECD countries.

When comparing among different regions of non-OECD countries (cf. Table 4), it is obvious that Asia constitutes the largest portion, about 54% of the energy consumption. Also, in term of growth rate, it is 3.7% p.a., the highest among all the regions.

From Table 4, it was seen that developing countries are consuming more energy, while among the developing countries, Asia region consumes the most. Table 5 presents the comparison of energy consumption patterns for G8 developed countries and Southeast Asian developing countries. In term of per capita energy consumption, the values of developed countries are very much higher than the developing countries. While among the developing countries, the per capita energy consumption of Malaysia is 106.3 million Btu, which is relatively high compared to the other Southeast Asian countries (except Brunei and Singapore) that generally lower than 60 million Btu.

Table 5: Comparison of energy consumption pattern in selected countries, 2005

Country	Primary energy consumption	
	Per capita (million Btu)	Energy intensity (Btu per 2000 US$)
G8 countries		
Canada	436.2	13,825
France	181.5	7,243
Germany	176.0	7,021
Italy	138.9	5,788
Japan	177.0	6,539
Russia	212.2	14,935
United Kingdom	165.7	6,048
United States	340.5	9,113
Southeast Asian countries		
Brunei	314.4	17,952
Cambodia	0.6	302
Indonesia	23.4	5,839
Malaysia	**106.3**	**9,253**
Myanmar	5.4	1764
Philippines	15.2	4,865
Singapore	457.1	15,444
Thailand	56.5	6,848
Vietnam	14.7	4,857

Source: EIA, 2007

In term of energy intensity, comparatively, the energy intensities of the developed countries are also generally higher than the developing countries, particularly for the case of Canada and Russia. Similarly, among the developing countries, it can be seen that the energy intensity of Malaysia is obviously higher than most of the developing countries, and in fact it is higher than quite a number of developed countries.

Table 6 shows the final commercial energy consumption in Malaysia during the Eighth and Ninth Malaysia Plans period, which covers the period of 2000 to 2010. In this respect, it includes the total energy delivered to final consumers, but excluding gas, coal and fuel oil used in electricity generation. The data show that energy consumption has grown from 1,244 PJ in 2000 to 1,632 PJ in 2005, and expected to grow further up to 2,218 PJ by 2010. In line with the rapid economic and population growths, the energy consumption growth rate for 2000-2005 was 5.6% p.a., and it is projected to increase up to 6.3% p.a. in 2005-2010.

Table 6: Final commercial energy demand by sector, Malaysia

Sources	Energy consumption (PJ)			Growth rate (% p.a.)	
	2000 (%)	2005 (%)	2010 (%)	2000-2005	2005-2010
Industrial[1]	477.6 (38.4%)	630.7 (38.6%)	859.9 (38.8%)	5.7	6.4
Transport	505.5 (40.6%)	661.3 (40.5%)	911.7 (41.1%)	5.5	6.6
Resident/ commercial	162.0 (13.0%)	213 (13.1%)	284.9 (12.8%)	5.6	6.0
Non energy[2]	94.2 (7.6%)	118.7 (7.3%)	144.7 (6.5%)	4.7	4.0
Agriculture/ Forestry	4.4 (0.4%)	8.0 (0.5%)	16.7 0.8%)	12.9	15.9
Total	1,243.7	1,631.7	2,217.9	5.6	6.3

Note :
[1]Include manufacturing, mining and construction.
[2]Include natural gas, bitumen, asphalt, industrial feedstock and grease.
Source: EPU, 2006.

In term of sectoral demand, no major change is expected during the period of 2000 to 2010, in which transport and industrial each constitutes about two fifths of the total consumption, and followed by residential/commercial, non-energy and agriculture/forestry.

With respect to per capita consumption, in term of final commercial energy demand, it was 52.9 GJ in 2000, then rapidly increased to 62.2 GJ in 2005. In line with the projected strong national economic growth, it is projected to further escalated to 76.5 GJ by 2010, more than 40% increase over the 10-year period from 2000 to 2010 (EPU, 2006).

INTERNATIONAL COOPERATION IN HANDLING GLOBAL WARMING ISSUES

Global warming and climate change are the two greatest issues to mankind currently. The urgency to fight against them has drawn serious attentions from leaders, scientists and individuals all over the world. In fact, the event that for the first time drawing attentions from the world on the global warming and climate change issues can be traced back to the first “World Climate Conference” organized by the World Meteorological Organization (WMO) in

1979. The conference expressed concern that "continued expansion of man's activities on earth may cause significant extended regional and even global changes of climate", and it called for "global cooperation to explore the possible future course of global climate and to take this new understanding into account in planning for the future development of human society" (IPCC, 2004). Subsequent to the said conference, various international efforts have been taken to monitor the climate change and to mitigate it. In 1988, the IPCC was set up and followed by the adoption of the United Nations Framework Convention on Climate Change (UNFCCC).

Presently the primary international policy framework against global warming and climate change is the UNFCCC, specifically the Kyoto Protocol, which sets emission limits for many of the world's most economically developed nations. Under the Kyoto Protocol, the participating developed countries are committed to reduce their GHG emissions on an average of about 5% by the target years of 2008 to 2012 (UN, 1998).

For post-Kyoto Protocol, during the United Nations Climate Change Conference 2007 held in Bali, Indonesia, it was decided to adopt the Bali Roadmap, which charts the course for a new negotiating process to be concluded by 2009 that will ultimately lead to a post-2012 international agreement on climate change (UNFCCC, 2007).

Also, during the G8 Summit 2007 held in Heiligendamm on 6-8 June 2007, the participating countries have agreed to consider seriously the target of halving of GHG emissions by 2050 (G8, 2007). Presently, the common global target is to cut the GHG emissions, particularly CO_2 emissions, by 50% of the present level by year 2050. In this respect, Japan has launched the national campaign of 'Cool Earth 50', which targeting to cut the CO_2 emissions up to half of the present level, by the year 2050. Also, the State of California of the United States is aiming to cut the emission to 80% below 1990 level, while London has set the target of 60% carbon emission reduction from 2000 level, both with the common target year of 2050 (TMG, 2006).

Presently the international policy frameworks on combating climate change are focusing on the developed countries. However, due to rapid increase of GHG emissions from developing countries (cf. Table 1 and Table 2), particularly for the case of China and India, there are increasing concerns on the necessity to cap emissions from the developing countries. For the case of Malaysia, Malaysia is one of the 172 countries signed the Kyoto Protocol but is not within the 35 countries that have committed to cap their emissions.

In spite of the absence of international commitment on the cap of CO_2 emissions, Malaysian Government has been continuously promoting energy efficiency, usage of renewable energy and combating climate change. In this respect, Malaysia is one of the 16 countries signed the *Cebu Declaration on East Asian Energy Security Cebu, Philippines, 15 January 2007* (ASEAN, 2007). Under the Cebu Declaration, the participating countries officially acknowledged the energy and climate change issues. All the countries concerned have agreed to make concerted efforts to improve energy efficiency, to promote alternative and renewable energy, and to mitigate GHG emissions.

ROLES OF URBAN PLANNING IN HANDLING ENERGY AND CARBON DIOXIDE ISSUES

Urbanization, Energy Consumptions and CO_2 Emissions

The most significant increase of energy consumptions and GHG emissions is taking place in cities, where rapidly expanding populations enjoy higher living standards and material affluence than people in the rural areas (Fong et al., 2007a; IGES, 2004). With respect to GHG emissions, Larson (2007) reported that the share of GHG emissions in building sector, thus in urban area, is in the range 20% to 25%, and this would be higher in developed countries. It is therefore clear that strategies for the reduction of energy consumption and GHG emissions would have to be focusing on urban sector, which is the main source of energy consumptions and GHG emissions.

Rapid urbanization is in progress all over the world, and the urban population is expected to continue to increase. In 2000, world urban population was about 2.9 billion (47.2% of world population) and it is expected to rise to about 5 billion (60.2% of world population) by 2030 (cf. Figure 3). During the period of 2000-2030, the world urban population is projected to grow at an average rate of 1.9% per year (UN, 2002).

Although concentration of people in cities brings advantages in terms of work and modern conveniences, it causes deterioration of living standards by various environmental problems, and global environmental problems that spread beyond national borders (AIJ, 2005). Thus urban environmental problems are significant elements in global environmental problems. If no immediate action be taken in cutting down the energy consumptions in urban sector, the impacts on climate change and other associated adverse impacts on the global, regional and local environments would be getting worse.

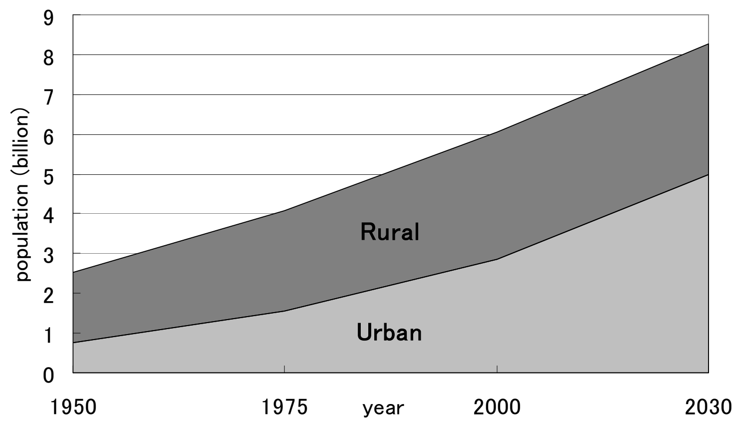

Figure 3: World urban and rural population, 1950-2030 (UN, 2002)

Rapid urbanization has resulted in more rapid change of microclimate in the urban areas. One of the phenomena is the UHI effect whereby a zone of higher air temperature is found in the central area of a city, displaying temperature contours like an island of heat. The world average temperature increase due to UHI effect is 0.006°C (IPCC, 2007). There are many factors contributing to the occurrence of UHI phenomenon, and energy consumptions and CO_2 emissions are among of the main factors, whereby the heat generated by the consumption of energy by air-conditioning equipment, lighting systems, automobiles, factories, etc. is released into the atmosphere (AIJ, 2005).

Although urban energy consumption is one of the main causes of UHI phenomenon as well as global climate change, unfortunately, presently the nature of energy use in and GHG emissions from cities is still not well understood. Although a number of research projects on sectoral energy use for industries, urban transportation and so on have been conducted from the viewpoint of managing air pollution, an overall picture of energy consumption and CO_2 emissions is still missing (IGES, 2004). Due to the growing concern about GHG, it is thus vital to understand energy use at city level in greater detail and to take GHG emissions into consideration so that systematic actions can be implemented in the urban planning process. In this respect, the present authors have carried out several studies focusing on the topics of energy conservation and CO_2 reduction (Fong et al., 2007a~2007g; Ho 2005 & 2007; Ho and Fong, 2007; Kimura et al., 2005, Matsumoto et al., 2007).

Urban Planning, Energy Consumptions and CO_2 Emissions

The issues of global climate change and UHI phenomenon has drawn many concerns among policy makers, urban planners and scientists on the importance of promoting low carbon city. Researchers and policy makers responsible for climate change and energy modeling have used the term low carbon society in 2003 when the developed nations announced a target for reducing CO_2 emissions in order to stabilize the world climate. Low carbon society project have been initiated by Japan/UK collaboration to draw out comprehensive vision and definition of low carbon society (NIES, 2006).

Many scientific research works have been carried out to investigate the urban CO_2 emission scenarios, and to study the methodologies for reducing urban energy consumptions and for achieving low carbon city. From these studies, it is obvious that urban planning is playing an important role in creating a low energy consumption and low CO_2 emission city. It is found that there are several urban planning related factors can determine the extent and nature of energy use and CO_2 emissions in cities, as explained below (Fong et al. 2007a~2007g; Ho 2005 & 2007; Ho and Fong, 2007; IGES, 2004):

Compactness and density of development

The compactness and density of urban development has very significant influence on transportation system, thus influencing the energy consumption and CO_2 emissions. A highly compact city facilitates transit oriented development (TOD) that directly reduces the private vehicle trip and reduces the energy consumptions and CO_2 emissions from transportation sector. The compactness of urban development also influences the district heating and cooling using co-generation systems. In this respect, urban sprawl results in the necessity of lengthy distribution systems, and thus undermines efficient energy use. However, energy efficiency could be achieved without needing high rise development. High rise development may not achieve high energy efficiency due to usage of highly energy intensive construction materials, which will greatly increase energy investment in infrastructure and may have high heating and cooling requirements. Thomas and Potter (1977) suggested that a pedestrian cluster of 20,000 to 30,000 people provides a sufficient threshold for many facilities without needing high rise development. Ho and Fong (2007) reported that density of 25 dwellings per hectare would allow facilities with catchment area of 8,000 to 14,000 to be within 600 m from all homes.

Urban structure

Urban structure and urban functions affect energy use, and thus CO_2 emissions, as they influence transportation systems. Mixed land use (residential, commercial, industrial, etc.) results in different energy use than does segregated land use. A reduction of physical separation of activities has been urged in nearly all studies of energy and spatial structure. Urban zoning policies and industrial relocation from city centers to suburb areas significantly influence the travel demand and energy use. Spatial strategies such as compact cities and TOD are effective in reducing energy demand for transportation. However, any saving from transportation energy requirement must not be overweighed by losses in economies of scale including energy economic of scale.

Settlement pattern

Comparative analyses of different urban structures suggest that energy efficient settlement pattern would consist of small to medium sized settlement or settlement clusters. Within settlements, over-concentration should be avoided. Residential areas should be planned around more disperse clusters of employment and services in relatively compact urban sub-units. However, high densities would not necessarily be a feature of this settlement pattern.

Transportation system

Transportation system is one of the key factors affecting the urban energy consumption and CO_2 emissions. As mentioned above, transportation system is very much depending on the urban structure. Ho and Fong (200) pointed out that increased density favored public transportation because of critical mass. His findings showed that a linear grid form may combine high density along the routes served with moderate overall densities, compatible with high quality environment. By doing so, a shift to public transportation can be done easily. Also, energy implications of transportation systems depend on a number of factors, such as the availability of infrastructure for rail and road networks, mass transportation systems, the share of public and private transportations, as well as the role of alternative fuel vehicles. Besides, socio-economic factors such as income are also influencing the transportation pattern. In most of the developing countries, rising incomes and perception of social status through car ownership have resulted in cars dominated transportation. This trend results in increased demand for transportation and eventually increases the urban energy demand and CO_2 emissions.

Income level and lifestyle

Past research on the relationship between income and energy use at the national scale has clearly demonstrated that there is a strong correlation between per capita commercial energy consumption and GDP (IGES, 2004). It is generally accepted that per capita energy use increases with income. High income is associated with better lifestyles and higher material affluent, which eventually result in increased energy use and CO_2 emissions.

Building technologies and floor space use

Building-related technologies such as air conditioners, district heating and cooling systems, insulation systems and other building energy management systems have significant effects on energy use. Services such as lighting and space heating/cooling depend directly on floor space, whose use depends on a number of factors such as real estate market prices, business culture and socio-cultural factors.

ENERGY AND CARBON DIOXIDE EMISSION CONSIDERATIONS IN THE URBAN PLANNING PROCESS IN MALAYSIA

Spatial Planning Framework in Malaysia

In Malaysia, development planning is practiced at three tiers of government as shown in Figure 4. At the national level, development planning in the country operates within the stated goals outlined in long-term Vision 2020 and the Outline Perspective Plans (OPPs), then followed by the Malaysia Plans, National Physical Plan (NPP) as well as the other sectoral policies/plans.

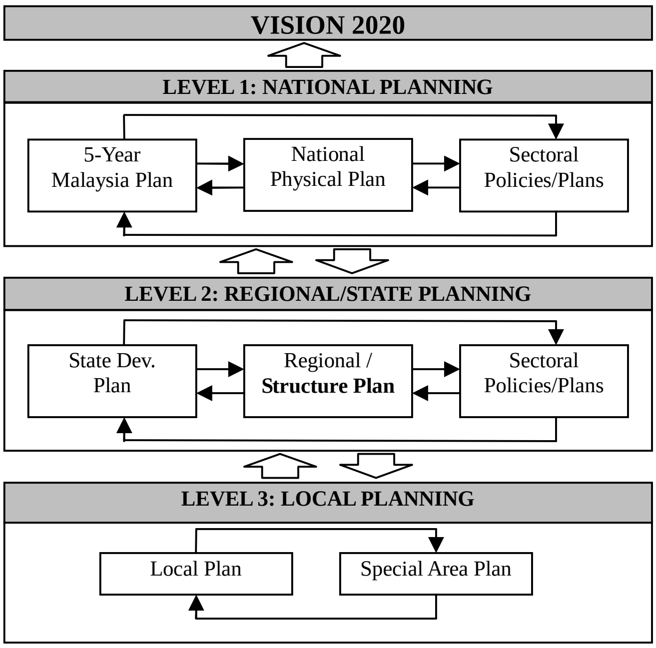

Figure 4: National development planning framework of Malaysia (JPBD, 2005)

In this respect, spatial development is mainly guided by the NPP. In order to achieve the goals of NPP, which is to establish an efficient, equitable and sustainable national spatial framework to guide the country towards achieving developed nation status by 2020, four mutually supportive objectives have been identified as follows:

1. To rationalize national spatial planning for economic efficiency and global competitiveness;
2. To optimize utilization of land and natural resources for sustainable development;
3. To promote balance regional development for national unity;
4. To secure spatial and environmental quality and diversity for a high quality of life.

In 2006, National Urbanization Policy (NUP) was formulated to complement the NPP. NUP serves as the main thrust for all urban planning and development activities in Peninsular Malaysia including development plans at the state and local level. This policy outlines the thrusts, policies, measures and implementation plans to coordinate and manage the urbanization process of the country. It guides and coordinates the planning and urban development of the country to be more efficient and systematic, particularly to handle the rapid increase of urban population, with emphasis on balancing the social, economic and physical development within urban areas. It also serves as the foundation to encourage racial integration and solidarity for those who reside in the urban areas.

At the state level (cf. Figure 4), development is guided by the Structure Plans and sectoral policies that are articulated from time to time. Local level planning is carried out in the form of statutory development plans such as the Local Plans and Special Area Plans for the local authority areas. Structure Plans distribute the expectation of development within each state and propose major economic and infrastructure projects for the states. The time perspective for Structure Plans is 20 years commensurate with the time perspective of Vision 2020. (JPBD, 2005)

Absence of Energy Consumption and CO_2 Emission Consideration

Presently most of the developed countries are committed to cut down their CO_2 emissions as stipulated under Kyoto Protocol as well as the recent declaration during the G8 Summit 2007 in Heiligendamm, Germany (G8, 2007). In this respect, developing countries are still lapsed behind most of the developed countries. However, being a country of responsible, Malaysia, one of the fastest growing developing countries in Southeast Asia, is continuously putting aggressive efforts in combating global warming. This section examines the present efforts in controlling energy consumptions and CO_2 emissions in

Malaysia, from the perspective of spatial planning.

As mentioned above, spatial development in Malaysia is mainly guided by the NPP. Presently, there is no specific policy related to energy conservation and controlling of CO_2 emissions in the NPP. However, there are several principles that have indirect implications on energy conservation, namely *Policy 3: Maximize use of existing infrastructure*, *Policy 6: Favor public transport over private transport*, and *Policy 7: Compact urban forms*.

For the case of NUP, although NUP is a comprehensive plan, there is also no policy directly referred to energy conservation and reduction of CO_2 emission. Policies that may have indirect implications on energy planning are found in Policy Thrust 1 and Policy Thrust 3 as follows:

Thrust 1 : Towards an efficient and sustainable urbanization
Thrust 2 : Development of a resilient, dynamic and competitive urban economy
Thrust 3 : Towards an integrated and efficient urban transportation system
Thrust 4 : Provide quality urban services, infrastructure and utility
Thrust 5 : Create a conducive urban living environment with a distinct identity
Thrust 6 : Effective urban governance

Part of *Policy Thrust 1 - Towards an Efficient and Sustainable Urbanization* highlighted the policy to promote national growth conurbation policy, and specific conurbation zones have been identified. The advantage of the national conurbation policy in term of energy conservation is that it promotes economic of scale and energy efficient system of these designated growth regions. Compact city development can be developed to optimize energy utilization in the region by reduction in movement and transportation energy.

Policy Thrust 3 - Towards an Integrated and Efficient Urban Transportation System promotes an integrated and efficient urban transportation system. As transportation sectors consumed more than a quarter of the total energy consumption in Malaysia, an efficient and comprehensive transportation system is vital. The current pressing issues are increasing in private car ownership and low utilization of public transportation. The policy thrust promotes the use of integrated public transportation system emphasizing on multi-modal transportation terminal, implementation of TOD development, provision of Park and Ride Terminals, use of environmental-friendly vehicles to reduce air pollution.

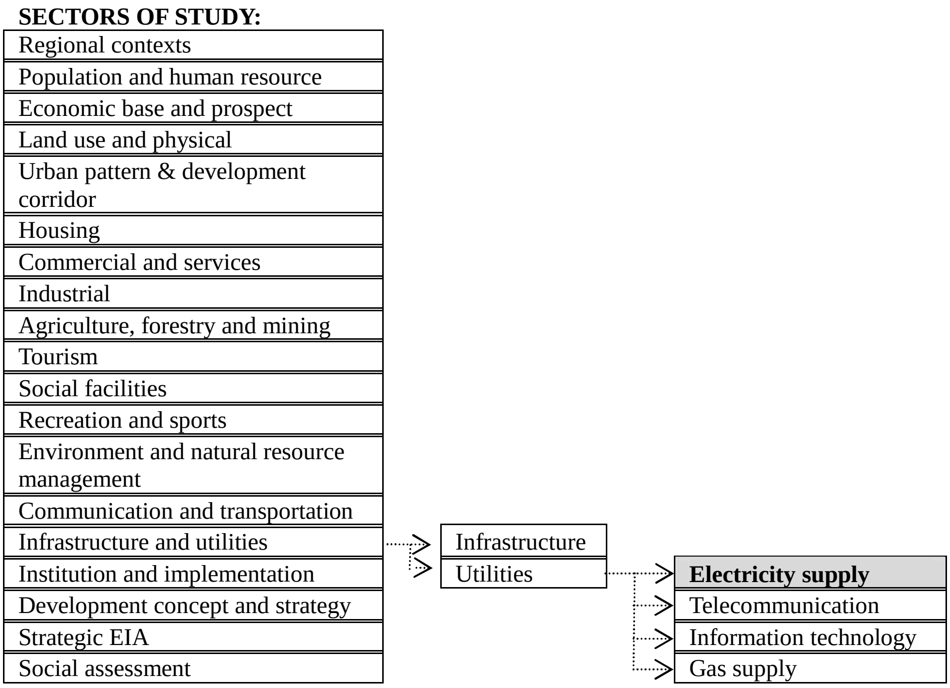

Figure 5. Energy sector (electricity supply) was a sub-sector under the utilities sector in the Johor Structure Plan 2001-2020 study (JPBD, 2001)

For the State and local levels, in the process of the preparation of Structure Plans and Local Plans, energy sector study very often focuses on fulfilling the energy demand rather than investigating measures to reduce the city-wide or region-wide energy consumption through an integrated approach. For example, in the study of Johor Structure Plan 2001-2020, energy sector was considered as one of the sub-sectors under the utility sector, but the study was in fact focusing on electricity supply rather than energy demand and supply as a whole (cf. Figure 5). Besides, energy issue was neglected in the environmental sector despite that the two most essential issues, energy and CO_2 emission, which have been widely recognized as global environmental issues that require immediate attentions from all parties.

On a whole, spatial planning framework in Malaysia should give more serious considerations on the issues of energy consumptions and CO_2 emissions. Although there are some policies in the NPP and NUP indirectly favor energy conservation, there is still no measure that directly focuses on promoting energy conservation/efficiency and capping CO_2 emission. Moreover, instead of promoting energy conservation/efficiency, in most of the Structure Plans, focuses are in fact put on fulfilling the continuously increasing energy demand so as to support the desired high economic growth rate.

CONCLUSIONS AND RECOMMENDATIONS

This paper highlighted the importance of energy conservation and reduction of CO_2 emissions from both global and Malaysia points of view. Although Malaysia is presently not a developed nation, and there is no clear commitment to cut down CO_2 emissions under any international framework, toward achieving the developed nation status under the Vision 2020, it is necessary to take concerted efforts to cap CO_2 emissions as part of the global efforts in combating global warming and climate change, while maintaining the desired economic and population growths.

The earlier parts of this paper pointed out that the main contributors to the global warming phenomenon are energy use and land use change. In this respect, urbanization is one of the essential aspects that must not be neglected in handling global warming issues, as the main portion of energy consumption and CO_2 emission is occurring in the cities. Hence, spatial planning that dealing with planning for land use and urban structure is playing a very important role in controlling energy consumption and CO_2 emissions in the urban systems.

While many countries have recognized the importance of the role of spatial planning in energy conservation and reduction of CO_2 emissions, in Malaysia, to date there is still no specific spatial planning policy that directly deals with the energy and CO_2 issues. Instead, in the urban planning process, efforts have been put mainly on fulfilling the high energy demand (which focusing more on electricity supply) so as to support the desired high economic growth. Hence, this paper aims to emphasize the importance of energy conservation and CO_2 reduction as the core considerations in the spatial planning process in Malaysia, from national till local levels.

In the preparation of Structure Plans, for instance, instead of trying to fulfill the expected high energy demand, measures should be taken to cut down the energy consumptions and CO_2 emissions, so as to achieve a balance between economic development and environmental conservation. Every proposal in the Structure Plan, to a certain extent, would have some impacts on the energy consumptions and CO_2 emissions in the planning area as a whole. For instance, a proposal to convert a forest area to commercial development would not only increase the energy consumption and CO_2 emission in the area concerned, but will also reduce the capacity of carbon sink due to the loss of green areas. Hence, due consideration must be taken on the impacts of each proposal on energy consumptions and CO_2 emissions. In this respect, it is necessary to develop and incorporate a decision making tool to assess the overall impact of development plans (or proposal options) on the city or regional level energy consumptions and CO_2 emissions as a whole. This decision making tool should be able to assist the decision makers as well as the other relevant stakeholders in making best choices of development options with due considerations on both economic and environmental aspects.

For the development of this decision making tool, it is necessary to develop a comprehensive model that able to provide a holistic analysis on various development options upon the overall urban energy consumptions and CO_2 emissions. In this respect, the present authors have developed a comprehensive but reasonably simple simulation model that suitable to be applied in the urban planning process in Malaysia, and parts of the research outputs are reported in Fong et al. (2007a & 2007b) and Ho and Fong (2007).

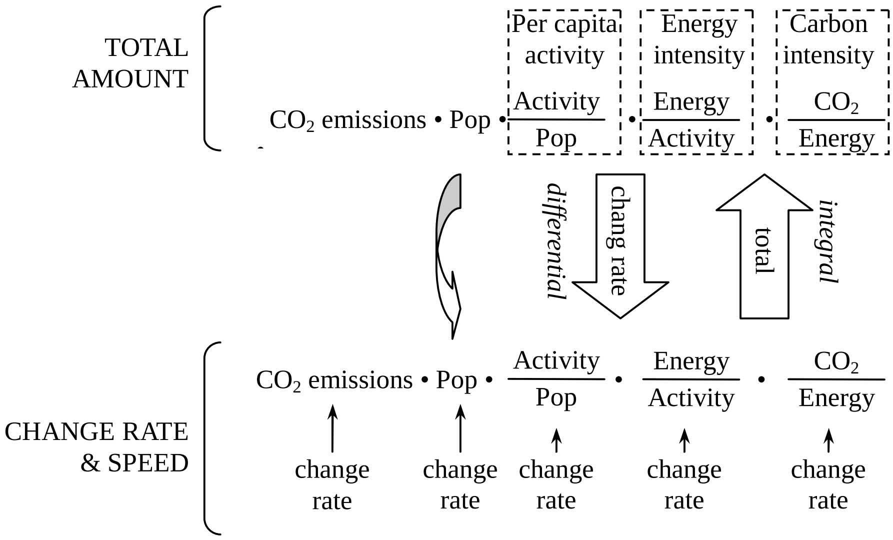

Figure 6: Concept of Kaya Identity (Source: NIES, 2006)

There are many strategies, in general, can conserve energy and reduce CO_2 emissions through spatial planning. For the case of Malaysia, being a developing country, economic development is no doubt the most important consideration in any development plan. Hence, it is vital to identify the best practice with minimum energy consumption and CO_2 emission while achieving the desire economic growth. In this respect, the concept of the Kaya Identity (NIES, 2006) would serve as an important guide in achieve a low energy consumption and low CO_2 emissions society under the concept of low carbon city. The Kaya Identity involved 3 main concepts, namely *per capita activity*, *energy intensity* and *carbon intensity* (cf. Figure 6). From the concept, it is clear that in order to reduce CO_2 emission by reducing per capita activity is not feasible for developing countries like Malaysia. Instead, it is important to reduce CO_2 emission by reducing energy intensity and carbon intensity.

In order to examine the relationship between energy and spatial planning, it is necessary to look into more detail variables of both of these aspects. The three main components in Figure 7 define the interrelationship between energy demand and spatial structure, and these are *(1) Energy demand and supply*, *(2) Urban form and other aspect of built environment*, and *(3) Mechanism of interaction between the energy system and spatial structure*. Demand and supply of energy will influence urban form. The configuration of urban form will affect the interaction of spatial structure and system interaction. It will then form a cyclic cycle in the near future when technology is more advance and appropriate as well as the demand for clean energy is more pressing.

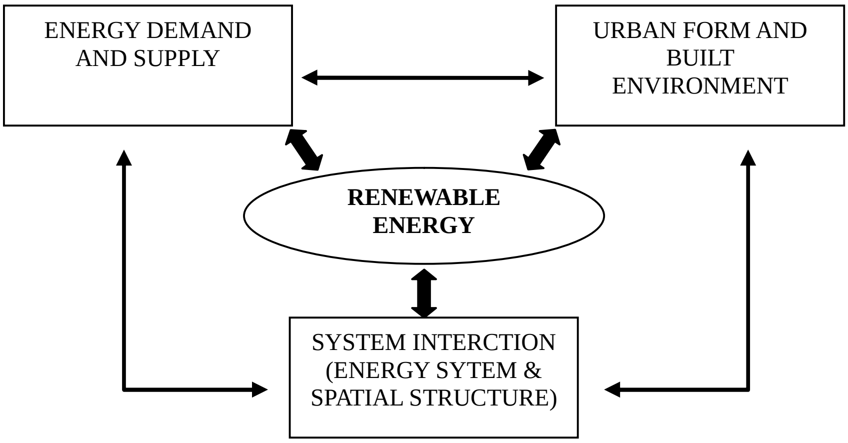

Figure 7: Interrelationship between energy and urban form (Ho, 2007)

This simplified concept attempts to illustrate the energy-spatial relationship, which in reality is far more complicated. It must also allow feedback systems that would themselves stimulate new developments and adjustments in the energy system. From the concept, the most commonly explored interactions have been those between various attributes of urban form (size, shape and density) and energy requirement for transportation. The questions that arise are whether any anticipated society changes should be guided by planning intervention into socially desirable forms or whether land use planning control is used to ensure spatial structures, which are both efficient in their consumption of energy resources and realistic.

On a whole, while it is widely recognized that in achieving a low energy consumption and low CO_2 emission sustainable society, it is important to carry out continuous research on the energy saving technologies and measures in various energy consuming sectors such as transportation, industrial, commercial and residential, and more importantly, it requires a holistic analysis and clear understanding of the nature of the highest energy consuming and CO_2 emission sector i.e. urban sector as a whole. This paper thus serves as a starting point toward incorporating energy and CO_2 issues as the core part of spatial planning process in Malaysia, in achieving a low carbon sustainable society.

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