Planning for Low Carbon Cities  
- The case of Iskandar Development Region, Malaysia

Ho Chin Siong, Universiti Teknologi Malaysia, Malaysia  
Fong Wee Kean, Toyohashi University of Technology, Japan

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Abstract

Urban planners play the roles of developing functional and aesthetically pleasing cities with the highest and best use of land, and at the same time ensure that they are ecological friendly. It is important to develop low carbon cities to ensure low CO₂ emissions in the urban areas. The planning of South Johor Economic Region (SJER), which commonly known as the Iskandar Development Region (IDR) provides a good opportunity for urban planners to incorporate the ideas of low carbon cities in this proposed high growth region. This paper aims to explore the concept of low carbon cities and examine the scenarios toward the realization of sustainable cities.

Keywords: Low carbon cities, Sustainable cities, CO₂ emission, Iskandar Development Region

1.0 Introduction

With more than 3.2 billion people living in the cities for the first time, the world urban population now exceeds the number of people living in rural areas (Sandrasagra, MJ, 2007). By the year 2030, it is expected that over 60% of the world’s population will be living in towns and cities (UN, 2002). These urban environments are responsible for over 70% of overall carbon emissions. Hence, in order to tackle the issue of carbon emission, there is a need for global and national strategies for sustainability in urban environments – in both existing and new developments, and from inception to occupation.

Planning of low carbon cities involves creation of low carbon society (LCS) by promoting low carbon emission. In order to achieve a low carbon emission, effort to reduce CO₂ emission is most important as CO₂ is the most significant anthropogenic greenhouse gas (GHG) emitted in urban areas. The increases of CO₂ concentration are due primarily to fossil fuel use and land use change. Urban planning through land use planning and planning control can play vital role in implementing the idea of low carbon cities, particularly during the formulation of development plans. Spatial strategies in development plans adopt sustainable development principles such compact cities, eco-cities and Transit Oriented Development (TOD) and other concepts of energy efficient city. Some of these ideas use renewable energy are currently gaining popularity and have been incorporated in development plans of many newly planned cities.
Apart from spatial planning strategies, reduction in CO\textsubscript{2} emission can be done through non-spatial strategies such as the fuel or vehicle legislations using in the Low Carbon Fuel Standard (LCFS) and through standards for CO\textsubscript{2} limits in vehicle engine emissions, for example the use of hybrid vehicles. This paper focuses on the spatial strategies and aims to examine the concept of low carbon cities and explore the scenarios toward the realization of sustainable cities in the newly planned Iskandar Development Region, Malaysia.

2.0 Low Carbon Cities – Population and Economy Growths and CO\textsubscript{2} Emissions

The rapid increase of CO\textsubscript{2} emissions has caused many concerns among policy makers. In discussing ways to curb CO\textsubscript{2} emissions, most attention tends to focus on the role of affluence and population increase (Dietz and Rosa, 1997) on CO\textsubscript{2} emissions. Studies showed that population and economic growth are the major driving forces behind increasing CO\textsubscript{2} emissions worldwide over the last two decades. It is particularly true in developing countries where the impact of population on emissions has been more pronounced. On average, it is found that a 1% increase in population is associated with a 1.28% increase in CO\textsubscript{2} emissions (Anqing Shi, 2001). With such magnitude, global emissions are likely to grow substantially over the next decades. Thus, the international negotiation and cooperation on curbing the rapid growth of CO\textsubscript{2} emissions should take into consideration the dynamics of future population growth.

The reduction of global emissions will become a more challenging task as most developing countries and newly developing countries will be experiencing rapid economic growth in the next decades. Rising income levels are associated with a large upward trend in emissions. Thus, another potential policy intervention on the reduction of emissions could also be in the area of increasing the energy efficiency of economic production both in developed and developing countries. Without these policy considerations on the role of energy efficiency, economic growth alone could be leading to a further worsening of global CO\textsubscript{2} emissions.

Planning of low carbon cities needs to incorporate the ideas of low carbon society (LCS) and low carbon economy in urban areas. Researchers and policy makers responsible for our climate change and energy modeling have used the term low carbon society in 2003 when developed nations announced a target for reducing CO\textsubscript{2} emission in order to stabilize the world’s 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). Several scientific research works have been carried out involving reviewing GHG emission scenarios studies, studying methodologies in achieving LCS and sharing best practice and information between countries.

3.0 Global and Malaysian – Carbon Dioxide Emissions

Every country contributes different amounts of heat-trapping gases to the atmosphere. Table 1 shows that in general, total CO\textsubscript{2} continue to increase in most regions. The developed countries lead in total carbon emissions and emitted more than 50% of the world total carbon emissions. Countries in North America and Europe that consist mainly of developed countries emitted most of the anthropogenic greenhouse gases. Over the last decades, industrial development in Asia and Middle East has resulted in rapid increase of CO\textsubscript{2} emissions, with percentage change of more than 5% p.a. as compared with global
average of 1.6% p.a. from the year 1990-2003. Developing countries such as China, India, Russia and Brazil are in the fast transition stage of industrialization have contributed to this rapid increase.

Table 1: Total CO₂ emissions by region, 1990-2003

<table>
<thead>
<tr>
<th>Region</th>
<th>1990 million metric tons</th>
<th>2000 million metric tons</th>
<th>2003 million metric tons</th>
<th>% change p.a. 1990-2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>21,283.38</td>
<td>23,832.70</td>
<td>25,575.99</td>
<td>1.6%</td>
</tr>
<tr>
<td>Asia (excluding Middle East)</td>
<td>5,014.89</td>
<td>7,272.53</td>
<td>8,477.90</td>
<td>5.3%</td>
</tr>
<tr>
<td>Central America &amp; Caribbean</td>
<td>379.32</td>
<td>467.09</td>
<td>500.58</td>
<td>2.5%</td>
</tr>
<tr>
<td>Europe</td>
<td>-</td>
<td>6,002.02</td>
<td>6,277.17</td>
<td>1.5%</td>
</tr>
<tr>
<td>Middle East &amp; North Africa</td>
<td>926.96</td>
<td>1,474.34</td>
<td>1,645.98</td>
<td>6.0%</td>
</tr>
<tr>
<td>North America</td>
<td>5,274.41</td>
<td>6,232.06</td>
<td>6,257.98</td>
<td>1.4%</td>
</tr>
<tr>
<td>South America</td>
<td>537.47</td>
<td>757.03</td>
<td>740.45</td>
<td>2.9%</td>
</tr>
<tr>
<td>Developed Countries</td>
<td>-</td>
<td>14,623.79</td>
<td>15,043.57</td>
<td>1.0%</td>
</tr>
<tr>
<td>Developing Countries</td>
<td>5,839.34</td>
<td>8,475.59</td>
<td>9,810.41</td>
<td>5.2%</td>
</tr>
<tr>
<td>High Income Countries</td>
<td>10,452.47</td>
<td>12,123.43</td>
<td>12,420.82</td>
<td>1.4%</td>
</tr>
<tr>
<td>Middle Income Countries</td>
<td>-</td>
<td>9,204.17</td>
<td>10,486.71</td>
<td>1.1%</td>
</tr>
<tr>
<td>Low Income Countries</td>
<td>912.89</td>
<td>1,494.26</td>
<td>1,631.11</td>
<td>6.1%</td>
</tr>
</tbody>
</table>


Table 2 shows world average CO₂ emission was 4.1 metric tons per capita in 2003. Per capita emissions in developed nations such as Europe and North America are higher than the world average, while developing countries are still less than the world average, in the range of 2 to 4 metric tons per capita. Obviously, these uneven distribution of CO₂ emissions is a big challenge to the world community in finding effective and equitable solutions for global warming and climate change issues.

Table 2: Carbon dioxide emission per capita by region, 1990-2003

<table>
<thead>
<tr>
<th>Region</th>
<th>1990 metric tons per capita</th>
<th>2000 metric tons per capita</th>
<th>2003 metric tons per capita</th>
<th>% change 1990-2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>4.0</td>
<td>3.9</td>
<td>4.1</td>
<td>0.2%</td>
</tr>
<tr>
<td>Asia (excluding Middle East)</td>
<td>1.7</td>
<td>2.1</td>
<td>2.4</td>
<td>3.2%</td>
</tr>
<tr>
<td>Central America &amp; Caribbean</td>
<td>2.7</td>
<td>2.8</td>
<td>2.9</td>
<td>0.6%</td>
</tr>
<tr>
<td>Europe</td>
<td>10.1</td>
<td>8.1</td>
<td>8.5</td>
<td>-1.2%</td>
</tr>
<tr>
<td>Middle East &amp; North Africa</td>
<td>3.0</td>
<td>3.9</td>
<td>4.1</td>
<td>2.8%</td>
</tr>
<tr>
<td>North America</td>
<td>18.6</td>
<td>19.8</td>
<td>19.3</td>
<td>0.3%</td>
</tr>
<tr>
<td>South America</td>
<td>1.8</td>
<td>2.2</td>
<td>2.0</td>
<td>0.9%</td>
</tr>
<tr>
<td>Developed Countries</td>
<td>12.0</td>
<td>11.0</td>
<td>11.1</td>
<td>-0.6%</td>
</tr>
<tr>
<td>Developing Countries</td>
<td>1.5</td>
<td>1.9</td>
<td>2.1</td>
<td>3.1%</td>
</tr>
<tr>
<td>High Income Countries</td>
<td>11.8</td>
<td>12.8</td>
<td>12.8</td>
<td>0.7%</td>
</tr>
<tr>
<td>Low Income Countries</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>2.6%</td>
</tr>
<tr>
<td>Middle Income Countries</td>
<td>3.3</td>
<td>3.2</td>
<td>3.5</td>
<td>0.5%</td>
</tr>
</tbody>
</table>


Malaysia is a newly developing nation and one of the 172 countries that have signed the Kyoto Protocol to the United Nations Framework Convention on Climate Change on 12 March 1999 and further ratified on 4 September 2002, aimed at combating global warming. However, ratification does not imply a country has agreed to cap their emissions and Malaysia is not within the 35 countries that have agreed to cap their emissions.
Figure 1 shows the comparison of that Malaysia and other countries in terms of CO₂ emission per capita. Malaysia, with an average CO₂ emission of 6.2 metric tons per capita, is considered to be higher among the newly developing nation, and it is higher than the world average.

In spite of the absence of cap on emission, Malaysian government has been continuously promoting environmental stewardship in all development plans. Since the Eighth Malaysia Plan (2001-2005), the incorporation of environmental consideration into planning and development was intensified (EPU, 2001). Due to the continuous efforts to promote sustainable development, Malaysia is being ranked number 38 among 146 countries worldwide, which is second in Asia (after Japan), with the Environmental Sustainability Index (ESI) of 54 with regards to environmental sustainability (Yale University, 2005). Other multilateral environmental agreements and related amendments signed and ratified include the Stockholm Convention on Persistent Organic Pollutants, Montreal Protocol, on substances that deplete the ozone layer, Basel Convention on the trans boundary movement
of hazardous waste and their disposal, Rotterdam Convention on prior consent procedure for hazardous chemical and pesticides in international trade and the Cartagena Protocol on bio-safety.

Most developing countries and newly developing countries including Malaysia would consider that economic development must come first before handling environmental issues. Many of these countries, including India and China, are still building coal-fired power plants and still predominately promoting private transportation. Coal releases more CO\textsubscript{2} into the atmosphere than any other energy sources. Several automakers in these new developing countries are competing to provide affordable cars to the country's increasing number of middle class population. The rapid increase of private car ownership and falling percentage of public transportation users will further increase the country's CO\textsubscript{2} emissions in the future.

In Malaysia, emphasis was placed on improving environmental quality through better management in major areas of concern particularly air, water quality and solid waste management as well as the utilization of cleaner technologies (EPU, 2006). Concerted effort of Malaysian government in formulation of National Environmental Policy adopted in 2002 outlined strategies to propel country growth trends towards sustainable development and also the setting up of new Ministry of Natural Resources and Environment to consolidate 10 environmental and natural resources agencies under one administration to facilitate and manage environment and natural resources. However, environmental management is mainly carried out as environmental quality regulation such as measures to reduce occurrence of haze and reduction of pollutants (NO\textsubscript{x}, CO). Comprehensive low carbon emission policy is not mentioned officially. Although such environmental quality regulations and protecting forest resources and other initiatives do indirectly reduce CO\textsubscript{2} emission, it is necessary to look into low carbon society scenario more holistically.

Governments in developing countries are not completely neglecting to the importance of taking steps against global warming. As a developing country of responsibility, Malaysia attaches great importance to the issue of climate change, and has taken several initiatives to reduce carbon emissions and promote energy efficiency. Under the Ninth Malaysia Plan (2006-2010) (EPU, 2006), policy strategies are outlined to increase energy efficiency and promotion on the use of renewable energy. In terms of sustainable energy development, the energy sectors aimed to enhance its role as enabler towards strengthening economic growth. Source of fuel will be diversified through greater utilization of renewable energy. Emphasis was given to further reduce dependency on petroleum products by increasing use of alternative fuels. A more integrated planning approach was undertaken to enhance sustainable development of the energy sector. During the Eighth Malaysia Plan (2001-2005) (EPU, 2001), development of the energy sector was focused on ensuring a secure, reliable cost and effective supply of energy, aimed at enhancing competitiveness and resilience of the economy. Efficient utilization of energy resources as well as the use of alternative fuels particularly renewable energy, was further promoted. Energy related strategies were streamlined to moderate the impact of escalating oil prices on the economy.

Table 3 shows that transport sector is the largest consumer of energy in Malaysia, generally accounting for more than 40% during the period of 2000 to 2005. This is
followed by industrial and commercial and residential sector at about 38% and 13% respectively. The overall demand at national average is projected on the increasing trend of about 6.3% p.a. during Ninth Malaysia Plan period (2006-2010) to 2,217.9 PJ. Similarly, the per capita consumption increase from 52.9 GJ in 2000 will increase to 76.5 GJ per capita consumption in 2010 (EPU, 2006). The energy intensity (ratio of total primary energy consumption to gross domestic product) has also showed an increasing trend i.e. 5.9 GJ in 2000 to 6.2 GJ in 2005 (EPU, 2006). Although all the above demand parameters showed increasing energy demand to sustain economic growth, energy efficiency initiatives particularly in industrial, transportation and commercial sectors as well as government buildings are taken by government to achieve the aim of efficient utilization of energy resources. Similarly efforts were continued to promote the utilization of renewable energy (RE) resources such as Small Renewal Energy Power Programme (SREP) and Malaysia Building Integrated Photovoltaic Technology Application Project (MBIPV). All these projects will help to contribute to reduce CO₂ emission.

Table 3: Final commercial energy demand by sector in Malaysia, 2000-2010

<table>
<thead>
<tr>
<th>Sources</th>
<th>Peta Joules (PJ)</th>
<th>Percentage of the total</th>
<th>Growth rate (% p.a.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2000</td>
<td>2005</td>
<td>2010</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>2005</td>
<td>2010</td>
</tr>
<tr>
<td>Industrial¹</td>
<td>477.6</td>
<td>630.7</td>
<td>859.9</td>
</tr>
<tr>
<td>Transport</td>
<td>505.5</td>
<td>661.3</td>
<td>911.7</td>
</tr>
<tr>
<td>Resident/commercial</td>
<td>162.0</td>
<td>213.0</td>
<td>284.9</td>
</tr>
<tr>
<td>Non energy²</td>
<td>94.2</td>
<td>118.7</td>
<td>144.7</td>
</tr>
<tr>
<td>Agriculture/Forestry</td>
<td>4.4</td>
<td>8.0</td>
<td>16.7</td>
</tr>
<tr>
<td>Total</td>
<td>1,243.7</td>
<td>1,631.7</td>
<td>2,217.9</td>
</tr>
</tbody>
</table>

Note:
¹ Include manufacturing, mining and construction.
² Include natural gas, bitumen, asphalt, industrial feedstock and grease.

In spite of these efforts, Table 4 showed that CO₂ emission in Malaysia is still relatively high in term of percentage change (120%) as compared to Asia (35.1%) and the world (12.7%). Although the per capita CO₂ emissions are still lags far behind developed countries. Malaysia, with the per capita emission of 5.4 metric tons is still higher than the global average of 3.9 metric tons per capita and Asian average of 2.2 metric tons per capita in the year 2000. Figure 2 shows the rapid increase of CO₂ emissions in Malaysia, and it is expected that the emissions will continue at higher rate with higher population and economic growth rates.

Table 4: CO₂ emissions in Malaysia as compared to Asia and the world, 2000

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Malaysia</th>
<th>Asia</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ emissions</td>
<td>Total 2000 (mil. toe)</td>
<td>123.6</td>
<td>7,837.0</td>
</tr>
<tr>
<td>% change since 1990</td>
<td>120.3</td>
<td>35.1</td>
<td>12.7</td>
</tr>
<tr>
<td>Per capita (2000)</td>
<td>5.4*</td>
<td>2.2</td>
<td>3.9</td>
</tr>
<tr>
<td>Cumulative CO₂ emissions (million metric tons)</td>
<td>Fossil Fuels &amp; cement</td>
<td>1,714</td>
<td>175,087</td>
</tr>
<tr>
<td></td>
<td>From land use change</td>
<td>20,654</td>
<td>163,621</td>
</tr>
<tr>
<td>CO₂ emission by sector (as % of total emission)</td>
<td>Transportation</td>
<td>26.2%</td>
<td>13.3%</td>
</tr>
<tr>
<td></td>
<td>Industry &amp; Construction</td>
<td>23.1%</td>
<td>24.7%</td>
</tr>
<tr>
<td></td>
<td>Electricity</td>
<td>25.5%</td>
<td>40.1%</td>
</tr>
</tbody>
</table>

*The value is different from that indicated in Figure 1 due to different source of information and base year
4.0 Iskandar Development Region

4.1 Background

In order to plan for low carbon cities in Malaysia, it is more effective to look into the urban areas as they are engines of economic growth as well as main contributors to CO₂ emission. In the case of Malaysia, the natural resource management through spatial planning approach integrates environmentally sustainable development concepts. These strategies are incorporated into the National Physical Plan and then translated into structure plans where it also identify and manage environmental sensitivity areas (ESAs) including forest and green lung reserves. Major urban conurbations are identified and three economic growth areas are demarcated in Peninsular Malaysia as regions or sub-regions where it will develop to be globally competitive. The South Johor Economic Region (SJER), which commonly known as the Iskandar Development Region (IDR), is one of these economic growth centers to be developed as an integrated global node of Singapore and Indonesia (cf. Figure 3)

The IDR covers an area of about 2,216.3 km². The development region encompasses an area about 3 times the size of Singapore and two times the size of Seoul Metropolitan Area. IDR covers the entire district of Johor Bahru, and several sub-districts (mukim) of Pontian (cf. Figure 4). The Planning Area falls under the jurisdiction of five local planning authorities, namely Johor Bahru City Council, Johor Bahru Tengah Municipal Council, Pasir Gudang Local Authority, Kulai Municipal Council and Pontian District Council.

Figure 2: CO₂ emission in Malaysia, 1990-2002
(Source: Energy Information Administration (2007))

Figure 3: IDR and the surrounding region – Singapore and Riau of Indonesia
As shown in Figure 5, there are a total of five (5) flagship zones proposed as key focal points for developments:

a) Flagship Zone A: Johor Bahru City Centre (new financial district, central business district, Danga Bay integrated waterfront city, Tebrau Plentong mixed development, causeway)

b) Flagship Zone B: Nusajaya (Johor state administrative centre, medical hub, educity, international destination resort and southern industrial logistic cluster)

c) Flagship Zone C: Western Gate Development (Port of Tanjung Pelepas (PTP), 2nd Link (Malaysia/Singapore), Free Trade Zone, RAMSAR World Heritage Park and Tanjung Piai)

d) Flagship Zone D: Eastern Gate Development (Pasir Gudang Port and industrial zone, Tanjung Langsat Port and Technology Park and Kim-Kim regional distribution centre)

e) Flagship Zone E: Senai-Skudai (Senai International Airport and Senai cargo hub)

Each of these flagships has major urban centre. Among these urban centers are Johor Bahru City (financial district), proposed Nusajaya urban centre (new State administrative centre), Pasir Gudang/Tg. Langsat (port and industrial township) and Senai-Skudai/Kulai (transport and cargo hub). Four of the focal points will be located in the Nusajaya-Johor Bahru-Pasir Gudang corridor, which also known as the Special Economic Corridor (SEC).

The planning of these urban centers in the 5 flagship zones provides opportunities for planners to explore the ideas of low carbon cities in these proposed 5 core areas. With the proposal of relatively high plot ratio of 3.0-7.0 and promotion of mixed land uses at Johor Bahru, Nusajaya centers and local centers, it allows development of self-contained compact city. The corridor development along Johor Bahru – Nusajaya – Senai can also facilitate the TOD development in the region. Higher density and mixed land use are favorable for the implementation of compact city development as well as the use of combine heat power (CHP) and district cooling (DC). All the above measures will help to improve energy efficiency as well as reduction in CO₂ emission in the planned region.
Broadly, the economy in IDR may be divided into three (3) main sectors i.e. primary (agriculture, fishing, forestry/wetland and mining), secondary sector (food processing, basic metal processing, non-metal processing, wood processing) and tertiary sector (retail and transport). Currently, the two main economic growth sectors in IDR are manufacturing and services. The key sectors in the manufacturing sector that drives the IDR economy are electrical and electronic (E&E), chemical and chemical products (petrochemical, plastics, oleo chemicals) and food processing sub-sectors. They contribute 60% of the total value-added in manufacturing. These key sectors lead to the emergence of supporting or induced sectors such as retail, wholesale, hotels, restaurants and finance. In manufacturing, the induced sectors include fabricated metal products, non-metallic products and transportation equipment.

4.2 Development Policies Related to Low Carbon Cities

There are three main policies as stated in the master plan for IDR that known as the Comprehensive Development Plan for South Johor Economic Region, 2006-2025 (hereinafter referred as ‘CDP’), which have direct impact on low carbon scenario of the IDR development. Among these polices are energy efficient building, sustainable land use and transportation, and natural and green environment.

a) Energy efficient building and sustainable neighborhood design

In creating livable communities, energy efficient building and sustainable design guidelines are proposed in the IDR. In order to encourage builders to build energy efficient building, ‘green building rating’ will be used for residential units, and to introduce energy efficient mechanisms on older or existing buildings in the city. Green building is the practice of creating healthier and more resource-efficient models of construction, renovation, operation, maintenance and demolition.

Sustainable neighborhood design will be used and implemented to encourage developers to plan neighborhood with self-contained facilities to reduce the use of private vehicles and hence reduce transportation energy and CO₂ emission.

One of the key thrusts of IDR is to create livable communities that encompass quality housing, adequate facilities, quality services and a healthy, safe and lively environment. To this end, the CDP plans not only for the current needs of the population but also for the future, ensuring that inter-generational equity is also sensitively addressed.

b) Sustainable land use and transportation

Land use planning helps to integrate environmentally sustainable development concepts by promoting mixed land use and public transport (non-motorized vehicles) and compact city development. The use of zoning district system (base zoning district and special overlay zones) allows appropriate and compatible mixed use development by combining retail/service use with residential or office use in the same building or on the same site can help to reduce in between space movement. Hence it can also reduce transportation energy and CO₂ emission.
Transit Planning Zones is also introduced in city centre areas such as within Johor Bahru City Centre and Nusajaya City Centre to promote a combination of commercial and housing on the same site. It allows developments with increased intensity especially the residential component. This aims to support the strategy of encouraging city living and transit oriented development. Transit Planning Zone is area within the 400m radius of rail stations where transit oriented development can be pursued. This form of development will help to promote the use of rail transport.

In addition, incentives are also given to encourage sustainable pattern of urban regeneration development through Brownfield development in the existing urban centers of Johor Bahru, Senai and Skudai. It provides a broad range of uses and is intensified in terms of commercial plot ratio and densities to reflect its role as the centre of administration, business, commerce, and employment of IDR and the new growth centre within the Special Economic Corridor (SEC). This high density development will provide critical mass to support vibrant activity.

c) Natural and green environment

The natural and green environment in IDR covers a total of more than 150,000 ha. of green spaces. This include RAMSAR site (9,483 ha.), Pulai State Park (5,570 ha.), regional park (3,178 ha.), district park (1,514 ha.), town park (941 ha.) and local parks (204 ha.) as well as the agriculture areas. All these green spaces will play an important role as a carbon sink for this region.

RAMSAR site is wetland of international importance which are of rare and unique and for conserving biological diversity. The three RAMSAR sites in IDR are Pulau Kukup, Sungai Pulai and Tanjung Piai, which are the Rank 1 Environmental Sensitive Areas (ESA). This would be able to reduce CO₂ in the atmosphere. Other public green space amenities to the general public, the private open space (POS) which refers to private green areas particularly golf courses are another green space located in the urban areas. There are also substantial areas in IDR still under the category of agriculture, predominantly, oil palm worker or owners. Some of the areas are classified as Environmental Protection Zone where it requires further environmental control by virtue of their identification as Environmental Sensitive Areas (ESA). In addition, water catchments zone (catchments of Sultan Iskandar Dam) is a Rank 1 ESA and needs to be protected. All activities within the water catchments zone must be controlled and no industrial activities should be allowed.

4.3 Scenarios of CO₂ emissions from energy use

In realizing the vision of low carbon city, besides the real efforts to cut down the emissions, it is necessary to establish a database of CO₂ emissions. In this respect, it is necessary to develop a standard method for estimating CO₂ emission and benchmark of the present emission should be established, also, projection of the possible future emission trends should be carried out.

In this study, CO₂ emissions from energy use in IDR have been estimated based on an integrated approach, using the System Dynamic Model (SD Model). A computer programming software known as STELLA was used to construct the SD model for the
complicated urban energy consumption system, to estimate the CO₂ emissions from energy use in IDR and to forecast the future emission trends.

In this model, four major urban sectors i.e. residential, commercial, industrial and transportation, were taken as four main sub-models in the overall SD Model. These four sectors are interrelated with a number of variables such as population, economics, etc. and they are related to each other by various equations and assumptions.

The base year for this study on CO₂ emissions from energy use in IDR was 2005. Besides estimating the CO₂ emissions in 2005, in line with the planning period under the CPD, projections of CO₂ emissions from energy use in IDR were carried out for a period of 20 years from 2005 until 2025.

In developing the SD Model, the essential data were mainly obtained from the CPD and complemented by various other sources of data and some assumptions. The underlying assumptions adopted in this SD Model are as follows:

a) Only CO₂ from energy consumption were taken into consideration.
b) Emissions from primary sectors were omitted.
c) CO₂ emissions were calculated based on the consumptions of electricity, diesel, fuel oil, liquid petroleum gas (LPG), coal and coke, petrol and kerosene.
d) Population growth rate, economic structure and economic growth rate were based on the values adopted in the CPD.
e) In estimating the number of residential unit, it was based on the assumption of one household per residential unit.
f) Energy consumptions by commercial and industrial sectors were calculated based on energy consumption per unit of Gross Domestic Product (GDP).
g) Vehicle ownership rate of 564 units per 1,000 population.
h) Vehicles were classified into four categories i.e. motorcycle, car, bus and lorry.

For the forecast of CO₂ emissions, an initial simulation using the SD Model was carried out based on the ‘Business as Usual’ Scenario (BaU Scenario), which was according to the various population and economic targets adopted in the CPD. This scenario was assumed to be a ‘high growth scenario’ with high growth in all sectors (population growth at 4.1% p.a. and GDP growth at 8% p.a.) as envisaged by the Malaysian Government on the rapid development of IDR in the next 20 years.

As mentioned above, it is challenging to maintain the high economic and population while reducing the energy consumption and CO₂ emission. In order to examine the possible CO₂ emission reduction that can be achieved under the present target of high population and economic growths as reported in the CPD, besides BaU Scenario mentioned above, another two scenarios have been developed, namely Moderate Measure Scenario (MM Scenario) and Drastic Measure Scenario (DM Scenario). Table 5 presents the main assumptions made for each simulation scenario. Under MM Scenario, it was assumed that moderate measures such as improvement in energy efficiency, change of lifestyle, improvement of public transportation system, control of car ownership, and other environmental measures will be taken to reduce the energy consumption in all sectors. While in DM Scenario, it was assumed that similar measures as per MM Scenario will be
implemented, but with more drastic moves to cut down energy consumption and CO₂ emissions.

Table 5: Simulation scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Business as Usual (BaU)</th>
<th>Moderate Measures (MM)</th>
<th>Drastic Measures (DM)</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population growth</td>
<td>4.1%</td>
<td>4.1%</td>
<td>4.1%</td>
<td>– BaU</td>
</tr>
<tr>
<td>GDP growth</td>
<td>8%</td>
<td>8%</td>
<td>8%</td>
<td>– BaU</td>
</tr>
<tr>
<td>Residential sector</td>
<td>BaU</td>
<td>Energy saving up to 20%</td>
<td>Energy saving up to 40%</td>
<td>– Improved energy efficiency of home appliances</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>– Energy saving lifestyle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>– Passive building technologies</td>
</tr>
<tr>
<td>Commercial sector</td>
<td>BaU</td>
<td>Energy saving up to 20%</td>
<td>Energy saving up to 40%</td>
<td>– Improved energy efficiency of equipments</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>– Passive building technologies</td>
</tr>
<tr>
<td>Industrial sector</td>
<td>BaU</td>
<td>Energy saving up to 20%</td>
<td>Energy saving up to 40%</td>
<td>– Improved energy efficiency of equipments/machinery</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>– Shifting to low energy consuming industries</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>– Usage of renewable energy</td>
</tr>
<tr>
<td>Transportation sector</td>
<td>BaU</td>
<td>Energy saving up to 20%</td>
<td>Energy saving up to 40%</td>
<td>– Reduced vehicle population growth rate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>– Reduced travel distance by motor vehicle</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>through measures such as land use planning,</td>
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<td></td>
<td></td>
<td></td>
<td>improved public transportation system, car</td>
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<td></td>
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<td></td>
<td></td>
<td>pooling and other transportation policies e.g.</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>tolls, taxations, parking charges etc.</td>
</tr>
</tbody>
</table>

Table 6 presents the simulation results. From the simulations, it was found that the total CO₂ emissions from energy use in IDR in 2005 was about 6.6 million metric tons, with 53% from industrial sector, 34% from transportation sector, 11% from commercial sector and 2% from residential sector (cf. Figure 6). CO₂ emission per capita is estimated to be 4.9 metric tons, which is lower than Tokyo, Greater London and New York State that range from 5.8 to 10.8 metric tons per capita (cf. Table 7).

Table 6: CO₂ emissions from energy use in IDR, 2005 and 2025

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2005</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GDP/capita</td>
<td>CO₂/cap</td>
</tr>
<tr>
<td>BaU Scenario</td>
<td>50,251</td>
<td>4.9</td>
</tr>
<tr>
<td>MM Scenario</td>
<td>50,251</td>
<td>4.9</td>
</tr>
<tr>
<td>DM Scenario</td>
<td>50,251</td>
<td>4.9</td>
</tr>
</tbody>
</table>

Note: GDP in MYR
For the next 20 years, it is expected that the population and economy in IDR will be growing at very high rates as envisaged by the Malaysian Government. The GDP per capita in 2025 is expected to be double of 2005 value.

With the high economic growth rate, it is likely to entail in high productivity and high consumptions in all aspects including energy. Under BaU Scenario, by 2025 it is expected that the total CO₂ emissions from energy use in IDR would be about 27 million metric tons with per capita emission of 9.0 metric tons, which is much higher than the present emission levels of Tokyo and Greater London. As shown in Table 6, comparing to 2005, the total CO₂ emissions in 2025 is more than four times (410%) of 2005 level, and the per capita emission rate is also almost doubled over the 20 years period.

Table 8 shows the CO₂ emission trends over the 20-year projection period under BaU Scenario, MM Scenario and DM Scenario. For BaU Scenario, it can be seen that the proportion of industrial sector is getting smaller while commercial sector is getting larger compared to 2005. This is because the present manufacturing industry is focusing more on heavy industries such as oil & gas, cement, steel, etc. while according to the CPD, the
future industry would gradually change to service industry, which has lower energy consumption rates.

Under *MM Scenario*, it was assumed that the population and economic growth rates would be maintained as in Scenario 1 (cf. Table 5). However, due to the implementation of various energy saving measures, CO$_2$ emission will be quite significantly reduced. The 2025 CO$_2$ emission under *MM Scenario* is expected to be about 82% of *BaU Scenario* and the per capita emission will be only 7.4 metric tons compared to 9.0 metric tons under *MM Scenario* (cf. Table 6). However, comparing to 2005 level, the emission is still very high, 338% growth over the 20 years period. Comparing the emissions from each sector, similar to *BaU Scenario*, the share of industrial sector is lowered due to shifting of industrial activities to service industry.

Under *DM Scenario*, it was assumed that more drastic measures than *MM Scenario* are to be implemented. Under this scenario, CO$_2$ emission in 2025 will be further cut down compared to *BaU Scenario* (cf. Table 6). The CO$_2$ emission is likely to be cut down 35% from 27 million metric tons in *BaU Scenario* to about 17.5 million metric tons. The per capita CO$_2$ emission is also possible to be cut from 9.0 metric tons under *BaU Scenario* to 5.8 metric tons. However, due to the high economic and population growth rate, there is still no reduction of CO$_2$ emission compared to 2005, but an increase of 265%. In term of sectoral emissions, the share of each sector’s emissions is similar to *BaU Scenario* and *MM Scenario*.

From the above simulations, it can be seen that if the present high growth scenario of IDR is prevailing, CO$_2$ emissions from energy use in 2025 is likely to increase to about four times of 2005 level. However, if aggressive energy saving measures to be taken by all parties, it is possible to slower down the growth in CO$_2$ emission to about 65% of *BaU Scenario*, although the 2025 emission would still be about 265% of the present level (2005) of emissions (cf. Table 5).

### 5.0 Conclusion -Future Scenarios Towards Low Carbon Cities 2025

There are several strategies to achieve low carbon cities through sustainable development. In order to reduce CO$_2$ emission, the formulae in Kaya Identity may be used to achieve the target for a low carbon cities. The Kaya Identity involved 3 main concepts, namely per capita activity, energy intensity and carbon intensity (cf. Figure 7).

Hence in order to reduce CO$_2$ emission by reducing per capita activity is not feasible for developing region like IDR. IDR with current population growth rate of 4% p.a. and economic growth rate of 6-8% p.a. for the last 10 years may continue to grow until 2025 to achieve the objectives outlined in CPD to be strong sustainable conurbation of international standing (Khazanah Nasional, 2006). Therefore to plan for a low carbon city, it is important to reduce CO$_2$ emission by reducing energy intensity and carbon intensity of the cities.
Among the measures that may be able to reduce energy intensity are low energy building, establishment of recycling system, transit oriented development, and Brownfield development, as explained in further detail below:

**Low energy building**

Apart for low carbon building, it is also defined as building that uses about 30kWh/m² to 20kWh/m². Low energy buildings typically use high level of insulation in cold countries, energy efficient windows, low level air infiltration and heat recovery ventilation. In the case of tropical countries, passive solar building design techniques are used. As space cooling and water heating are highest percentage of household energy consumption, reduction of air conditioning and water heating can reduce the total energy demand significantly. This measure is already adopted as policy strategies in Livable Communities in the CPD for IDR.

**Establishment of recycling system**

Business has generated a lot waste using different type of refuse disposal – land filled and incinerators. Many countries such as Japan have successfully reduced landfill waste by about 75% p.a. In order to establish favorable recycling system in IDR, it is important to reduce waste generation as well as establish a system to recycle waste as resources. Public awareness and education on the importance of the recycling as well as setting up centers for collection of recycling are important to ensure the effective implementation.

**Transit development**

The linear spatial development pattern of IDR along the two main corridors Johor Bahru – Kulai - Pasir Gudang provides great opportunities to for the region to develop rail system and develop the urban centers based on TOD concept. The recent proposal for a Light Rail Transit along these corridors will help to promote the use of public transport to reduce
dependence on private vehicle usage. This form of TOD development may reduce traffic on the roads and revitalize urban neighborhood. The changing demographics and lifestyle of urban society of IDR is similar to developed countries that indicates trend of growing number of smaller households and retiring baby boomers who opts to live in smaller homes in urban areas. There is a trend of demand to revitalize denser and more convenient living choices or decentralized concentrated urban centers. This yuppies and new urbanized society desire walkable communities with easy access to transportation. This measure has also been adopted as one of the planning strategies of CPD (Chapter 16) to ensure viability of public transport.

**Brownfield development**

The urban regeneration involve redeveloping brown fields either those abandoned or low density and uneconomic use of land for higher density development. Urban infill development is gaining popularity not only in developed countries but also in Malaysia. Apart from energy efficient and reduction in CO\textsubscript{2} emission, this form of development allows the existing infrastructure and amenities to be used and also prevent urban inner city decay.

Among the measures that may be able to reduce carbon intensity include the usage of alternative fuels such as bio-fuel, and prevent deforestation and promote carbon sink, particularly for the RAMSAR site and Sungai Pulai wetland.

- **Use of alternative fuel – bio-fuel**

In order to create low carbon cities in IDR, it is important to look into potential of reducing dependence on fossil fuel. This is where economy in which CO\textsubscript{2} emissions from the use of carbon based fuels (coal, oil and gas) is significantly reduced. As Malaysia is a palm oil exporter nation, bio-fuel from palm oil provides a viable alternative for the government to consider. The optimal reduction is when the cities adopt zero carbon policies where any form of carbon emission is prohibited. Based on the CDP for SJER 2006-2025, IDR will experience high GDP growth of 8% p.a. as compared with the State average of 5.5 % p.a. (without SJER). In order to sustain such rapid economic growth, population will reach about 3 million by year 2025 and population growth rate is expected to be about 4.1% as compared with State average of 2.1% p.a. This will result in increases in energy demand due to industrialization and urbanization.

Low carbon intensity can also be achieved through the use energy efficiency measures. It also showed that energy efficiency could yield significant reduction in CO\textsubscript{2} emission at low cost and the substitution of renewable energy sources for fossils fuels and nuclear power including transport electrification. New technologies such as hydrogen solution power and carbon capture and storage should be involved in the near future.

A low carbon intensity may not always contribute to increase production cost for the enterprises. This is because a higher energy efficiency of low carbon energies, existing technological improvement, and increase cost of carbon fuels and the introduction of carbon taxes or carbon trading.
**Prevent deforestation and promote carbon sink – RAMSAR site and Sungai Pulai wetland**

Protection, preservation and enhancement of bio-diversity and natural green environment is an important policy in IDR. The total area of natural and green environment in IDR is more than 150,000 ha. including forests, mangrove areas, parks and open spaces as well as the agricultural areas. These green areas will play important roles as a carbon sink to absorb CO₂. Apart from the significance of Sungai Pulai Forest and wetland reserve of more than 9,000 ha. as world renowned designated RAMSAR site, it is also one of the main catchments areas for water supply to Singapore and Johor Bahru. Sg Pulai forest reserve consists of several areas including Kukup Island and Piai Cape (Southernmost of the Asia Continent), National Park of Piai and Permanent Forest of Sg Pulai.

All the above requires long term thinking and important of technological, institutional, and social change to ensure successful implementation. In order to achieve the environmental goal for the IDR it is important to set environmental targets for 2025. The key options to reduce CO₂ emission require possible combination of countermeasures on the energy demand and supply.

Apart from urban planning, roadmap to achieve low carbon cities require strong political will and decisive actions especially incentives of non spatial such as to promote energy efficiency, renewal energy, recycling and spatial policy such as TOD, regeneration/ Brownfield development, and energy saving building.

In the case of IDR, from the simulations, it is expected that if the present high growth scenario is prevailing, and if aggressive energy saving measures were not taken, by 2025 CO₂ emissions from energy use is likely to increase to about four times of the present level. In term of emission per capita, the present level of emission rate is quite low, only about 4.9 metric tons per capita, which is well lower than the major cities in the developed countries such as Tokyo (5.8 metric tons per capita) and Greater London (6.9 metric tons per capita). However, should the high economic and population growths as envisaged by the Malaysian Government is prevailing, and the society is enjoying material affluence without giving much attention on energy saving, it is projected that the emission rate would significantly increase to 9.0 metric tons per capita in 2025, very much higher than the present emission levels of Tokyo and Greater London. Nevertheless, if aggressive energy saving strategies were being drawn up and implemented in the government policies from national to local levels, and the general public are well aware of the importance of energy saving lifestyle, it is possible to bring down the CO₂ emission rate to 5.8 metric tons per capita in 2025 as shown in DM Scenario in Section 4.3. Moreover, if the present forests, open spaces and parks as well as the agricultural areas in IDR were well managed and conserved, the CO₂ emission rate could be further reduced to 5.6 metric tons per capita, lower than the present emission level of Tokyo and Greater London. Therefore as a proactive action, planning for low carbon cities measures should be adopted in the planning and implementation of the CPD to ensure a more sustainable urban conurbation in south Johor.
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