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Kyoto University
Study on Sustainable Low Carbon Society in Malaysian Regional Development

Janice Jeevamalar SIMSON
ABSTRACT

Malaysia is a fast developing Southeast Asian nation which has various new strategies and development plans in line with the government’s aim to achieve the ambitious goals of Vision 2020. The Malaysian Government has come out with the national spatial framework as an important physical guide in realising the national objective of sustainable growth with high income and employment. This framework together with the 10th Malaysian Plan and other sector policies are the drivers that will move Malaysia forward to become more competitive with other global economies. The 10th Malaysian Plan indicates the population of this county to be about 28.3 Million in 2010 with a population growth rate of 1.3% (2006-2010), and has a GDP growth rate of 5.7% per annum (2006-2008). The urban population consists of about 63% of the total population. More than half of the total land areas of Malaysia (59.9%) are forests which functions as a carbon sink. (Economic Planning Unit Malaysia, 2010)

Together with the current national development plans and strategies, Malaysia is also committed to a reduction of 40% in CO$_2$ emission intensity by year 2020 compared with its 2005 levels, as delivered by the Malaysia Prime Minister in COP 15 in Copenhagen, Denmark, 2009. This is in line with the impacts of climate change in Malaysia. The Intergovernmental Panel on Climate Change (IPCC) predicts that without further action to reduce greenhouse gas emissions the global average temperature will raise by further 1.8 to 4.0 degrees Celsius in this century. Climate change is also likely to impact agriculture, water resources and biodiversity. With this in mind, it is important to identify the possibility of implementing a Low Carbon Society (LCS) development in cities and regions in Malaysia. This thesis will go on to study the implementation of LCS in the southern most regions of Peninsular Malaysia; Iskandar Malaysia and the Federal Administrative Centre of Malaysia; Putrajaya.

The quantitative of CO$_2$ emission estimation and energy demand for the years 2005 and 2025 in Iskandar Malaysia Region by using the Extended Snapshot tool (ExSS). With this quantitative numbers the researcher was able to design Focus Group Discussions sessions with the Local Authority: Iskandar Regional Development Authority Malaysia. Following
this, the study then proposes counter measures which can be implemented in the Iskandar Malaysia Region to lower the CO$_2$ emission by 2025.

For the City of Putrajaya, the Socio-economic modelling tool of Community Extended Snapshot tool (C-ExSS) was used to estimate the energy demand and CO$_2$ emissions for the years 2007 and 2025 in Putrajaya. With the quantitative numbers from this tool, the researcher was able to two run FGD sessions with Putrajaya Corporation (PJC) and various stakeholders. And this enabled the researcher to propose six actions which can assist PJC reduce the CO$_2$ emissions by 2025. Each of this action proposes sub-actions and programs which PJC can implement.

As a conclusion the methodology of implementing A Low Carbon Society in Malaysia is demonstrated at a regional and city level in this study. This methodology can be practiced by other local authorities in Malaysia towards the goal of reducing CO$_2$ emission and move towards a LCS.
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“Cities and towns contribute significantly to climate change - from fossil fuels used for electricity generation, transport and industrial production, to waste disposal and changes in land use... How cities and towns are planned affects not just the health and well-being of their inhabitants, but the global environment and our prospects for sustainable development.”

-Ban Ki-Moon
Secretary –General United Nations
1 INTRODUCTION

1.1 Research Background

Global climate change was put on the international political agenda in 1992, and with that, the United Nations Framework Convention on Climate Change (UNFCCC) was agreed upon. Since then developments in both climate science and climate policies have been swift (Munasinghe & Swart, 2005). Following this, the Kyoto Protocol entered the climate change arena on 11 December 1997 during the Conference of Parties (COP-3) in Kyoto, Japan and by the end of 2010; the protocol had been ratified by 191 countries (UN Habitat, 2011).

As we step into the second decade of the new millennium, climate change together with rapid urbanization threaten with the exceptional negative impacts upon quality of life, economy and social stability of city dwellers (UN Habitat, 2011). The timing and magnitude of future climate change is uncertain; and some of its effects may be harmful, and some beneficial. It will have consequences for the human health, ecosystems, economic activity and social well-being (New Horizons in Regional Science 2006). Globally we already experience the exacerbating effects of climate change in the form of many weather related catastrophes namely; the increase in the duration and intensity of storms, sea-level rise, salt water intrusion which affects drinking water supplies, coastal erosion and the reductions in liveable land space (IPCC 2001).

Although there is widespread global recognition of climate change, there is a lack of knowledge and emotional engagement with the issue. Surveys conducted in the United Kingdom show that awareness and concern about climate change have increased over the past two decades, however in the context of other more immediate or tangible concerns (e.g. health, finances), climate change takes a low priority (Whitmarsh, Gill and Saffron 2011). There are two approaches for
dealing with climate change. One approach, is to mitigate the emission of greenhouse gases (GHGs), since the Industrial Revolution, human activities such as burning of fossil fuels have contributed to increases in the atmospheric concentrations of Carbon dioxide (CO₂). CO₂ is one of the more significant and long-lived GHG (IPCC 2001). The other approach is to adapt in anticipation of future climate change. Adaptive actions are those responses or actions taken to enhance the resilience of systems sensitive to changes in climate, thereby reducing the risks and taking advantage of the opportunities presented by climate change (New Horizons in Regional Science 2006).

To effectively reduce CO₂ emissions while keeping the economic growth, many countries have begun to search for a new development path; among which low carbon development (LCD) has become a widely advocated one. This low-carbon development is summarized in Figure 1.1, it is by consolidating various low-carbon related concepts from literatures which are adopted by different countries in the world. Low carbon economy is the first phase of this development when CO₂ emission in economy development is the main target.

![Figure 1.1: The phases of low carbon development](source: (Hu, Peng and Dequn 2011))
The second phase is the development stage known as low carbon society (LCS). During this phase governments should try to promote low carbon lifestyles and consumption patterns. This is also the stage when there is the introduction of various low carbon technologies. The move from the primary stage to this stage also involves the introduction of new energy resources such as renewable energy sources and the implementation of energy efficiency in appliances and lifestyle. This development stage is one that is now adopted by most nations in the world. To achieve the low carbon society status, a city or region needs to be low carbon in all aspects including economy, daily life, politics and culture. It is said, a low carbon community is the epitome of low carbon city (Hu, Peng and Dequn 2011).

In the move towards a low carbon society at the global level, detailed LCS scenarios have been proposed in several countries, targeting up to the year 2050 with reductions of around 50% compared to current emissions. A large number of municipalities around the world have their own low-carbon goals and plans targeting after 2020 as seen in Figure 1.2.
In countries such as Japan and United States, many states and cities have set their own targets in emission reduction. In Japan, the Prime Minister’s Office accepted candidates for “Environmental Model Cities” in April 2008, and a total of 82 municipalities applied with long-term low-carbon targets as a necessary condition (Gomi, Shimada, & Matsuoka, 2010).

The following chapters in this thesis, will discussing how Malaysia; a developing nation moves towards implementation of sustainable low carbon society policies in its aim to reduce CO$_2$ emission intensity and achieve low carbon cities and regions in this nation. The lowering of CO$_2$ emissions is not just focused towards the goal of reducing the effects of climate change but it is
also an important move towards sustainable development (Simson, Ho, Matsuoka, & Gomi, 2011)

Sustainability and climate are not the factors used to measure neither the national economy nor the health of the nation; and the world’s economy is still highly influenced by the price of oil. In 1987, Gro Harlem Brundtland in her report on ‘Our common Future’ has defined sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. For more than two decades since then, world leaders have been making efforts towards making development sustainable.

If the world is pictured to be a system which is connected by time and space, we can understand as to how something that happens in the Northern Regions; such as air pollution can affect the air quality in the Southern Regions, or how a conflict in the East could affect the peace in the West. On a smaller scale; take for example, a nation which has invested in green technology for transportation and has a good public transportation service and network (Simon & Stephan, 2008). This will lower the use of private vehicles, thus help reduce the amount of fuel combustion, which will lead towards lowering the energy consumed in this nation; in return this will not just lowers the CO$_2$ being emitted into the atmosphere, but it will also make communing a convenience for to the general population. The implementation low carbon society plays an important role towards enhancing sustainability and reducing the effects of climate change in urban dwellings, cities and regions (Simson, Ho, Matsuoka, & Gomi, 2011)

Malaysia a fast developing Southeast Asian nation, and has various new strategies and development plans in line with the government’s aim to achieve the ambitious goals of Vision 2020. The Malaysian Government has come out with the national spatial framework as an important physical guide in realising the national objective of sustainable growth with high
income and employment. This framework together with the 10th Malaysian Plan and other sector policies are the drivers that will move Malaysia forward to become more competitive with other global economies. The 10th Malaysian Plan indicates the population of this country to be about 28.3 Million in 2010 with a population growth rate of 1.3% (2006-2010), and has a GDP growth rate of 5.7% per annum (2006-2008). The urban population consists of about 63% of the total population. More than half of the total land areas of Malaysia (59.9%) are forests which functions as a carbon sink. (Economic Planning Unit Malaysia, 2010)

The 10th Malaysian Plan has identified a total of five (5) growth corridors; as seen in Figure 1.3. The planning of these urban agglomerations focuses on the development corridors around cluster and developing high economic sectors with clear competitive advantage to maximize impact based on common resources. It also facilitates private investment to develop priority industries especially related to service industries. The limited number of high density cluster or conurbation of five (5) main development corridors provides opportunities for urban planners to promote sustainable compact cities in line with low carbon city development principles. (Economic Planning Unit Malaysia, 2010)

![Figure 1.3: Location of five (5) economic development corridors in Malaysia](image-url)
Together with the current national development plans and strategies, Malaysia is also committed to a reduction of 40% in CO$_2$ Emission Intensity by year 2020 compared with its 2005 levels, as delivered by the Malaysia Prime Minister in COP 15 in Copenhagen, Denmark in 2009. This is in line with the impacts of climate change in Malaysia. The Inter-governmental Panel on Climate Change (IPCC) predicts that without further action to reduce greenhouse gas emissions the global average temperature will raise by further 1.8 to 4.0 degrees Celsius in this century. And Climate change is also likely to impact agriculture, water resources and biodiversity. With this in mind, it is important to identify the possibility of implementing a Low Carbon Society (LCS) development in cities and regions in Malaysia. This thesis dissertation will go on to study the implementation of LCS in the southern most regions of Peninsular Malaysia; Iskandar Malaysia and the Federal Administrative Centre of Malaysia; Putrajaya.

1.2  Research Objective

To begin this research, two objectives are set. Following are the two objectives of this research:

i. To develop a methodology where Low Carbon Society (LCS) scenarios can be developed and introduced by Local Authorities.

ii. To evaluate the methodology by applying it to two study areas.

The two study areas where this methodology is applied are as follows:

i. Iskandar Regional Development Authority (IRDA), a regional level Local Authority (LA)

ii. Putrajaya Corporation (PJC) a city level LA
1.3 Research Framework and Organization

With the aim of reaching the above mentioned objectives of this thesis the Research framework is designed. The research framework and how the ideas for this research are introduced in each of the chapters in this thesis are shown in Figure 1.4. Chapter 1 is the introductory chapter where the background about climate change and how it leads to the idea of Low Carbon Society is discussed.

Chapter 2 is the chapter that gives a descriptive outlook on the existing policies and guidelines which are environmentally related in Malaysia. This includes the National Policy on Climate Change, National Communication II and the National Green Technology Policy. These are some of the guidelines which will lead cities and regions in Malaysia towards the idea of Low Carbon Society.

Chapter 3 discusses the methodology which is developed to implement low carbon society in Malaysian regional Development. The methodology is divided into two main sectors, (i) quantification methodology and (ii) implementation methodology. Both these methodologies will be explained in detailed in this chapter. The tools used in this research will also be discussed here.

Chapter 4 discusses the case study of Iskandar Malaysia. This is a regional level LCS initiative. The socio-economic model known as; the Extended Snapshot (ExSS) tool is used to estimate the energy demand and the levels of CO$_2$ emission in the Iskandar Regional Development Authority’s (IRDA’s). The quantification methodology and implementation methodology are applied to Iskandar Malaysia and the application process and results are discussed.
Global Issue: Climate Change (CC)  
(IPCC 2001, IPCC 2007)

Evaluation of issue: Identify CO₂ is one of the more significant and long-lived GHG (IPCC 2001)

Action: Commitment in the Conference of Parties (COP) 15 Copenhagen (2005)  
• 40% reduction of CO₂ emission intensity by year 2020 compared to levels in 2005

Assessment: Existing Policy and Guidelines in Malaysia:  
• National Policy on CC  
• National Communication II  
• National Green Technology Policy

Prepare a Methodology for Implementing Low Carbon Society in Local Authorities  
• Quantification Methodology  
• Implementation Methodology

IRDA: A Low Carbon Region 2025, Sustainable Iskandar Malaysia  
• Estimation of CO₂ Emission Levels In 2005 & 2025  
• Actions to incorporate Low Carbon Policies into Development Plan.

PJC: Putrajaya Green City 2025  
• Estimation of CO₂ Emission Levels In 2007 & 2025  
• Implementation of Low Carbon Actions city wide

Conclusion and Future Direction

Issue at Global Level  
International Response to CC

National Level Response to CC

Methodology of Study

Regional Level LCS Initiative

City Level LCS Initiative

Conclusion & Future Direction

Chapter 1

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

Figure 1.4: Flow of Research Framework
Chapter 5 discusses the Case study of Putrajaya. This is a city level LCS initiative carried out by the Putrajaya Local Authority (LA) known here as the Putrajaya Corporation (PJC). The socio-economic model known as; the Community Extended Snapshot (C-ExSS) tool is used to estimate the energy demand and the levels of CO$_2$ emission in the Putrajaya. The quantification methodology and implementation methodology are applied to Putrajaya and the application process and results are discussed.

Chapter 6 presents the conclusion of this research. This chapter will also outline the possible future direction of this research.

The above mentioned six chapters will explain this research in the following pages of this thesis.
1.4 Reference for Chapter 1


Planning of low carbon cities contribute towards low carbon emission; demonstrating a high level of energy efficiency and use low-carbon energy sources and production technologies and also adopting patterns of consumption and behavior that are consistent with low levels of greenhouse gas emissions in the urban areas. The reduction in emission in the urban areas is imperative as \( \text{CO}_2 \) is the most significant anthropogenic greenhouse gas (GHG) emitted in urban areas. 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 green cities, green growth and other concepts of energy efficient city. Some of these ideas use renewable energy and uses of advanced green technology are currently gaining popularity and have been incorporated in development plans of many newly planned cities. The focus of planning low carbon cities is more pressing with current trend of rapid urbanization, and Local Authorities (LA) together with the government plays a very important role in the effort towards a low carbon society (LCS).

### 2.1 Sustainable Development and Low Carbon Society Vision in Malaysia.

Since independence in 1957, Malaysia adopted policies of industrialization and rapid urbanization with massive housing and township development in 1970s and 1980s. Many agriculture and plantation lands around the existing cities are developed into new township to cater the increasing demand of urban population. In addition, regional development authorities’ (RDAs) were also established to carry rural urbanization projects to develop the frontier regions especially in less developed states. Several rural towns such as Bandar Tun Razak (formerly known as Jengka town), Bandar Penawar, Mudazam Shah, Gua Musang are developed to serve these newly developed frontier regions.

In the mid 1990’s, the policy shift towards k-economy, Information & Communication Technology (ICT) development and Multi-media Super Corridor (MSC) development that enable Malaysia to evaluate sustainability of urban development by looking into possibilities of incorporating ICT technology and cyber city ideas. Many of mega urban development began to
look into intelligent cities and transport as well as other smart infrastructure. However, this concept was not fully implemented due to Asian currency crises and recession in the late 1990s. Under the recent New Economic Model, the government is seriously considering digital city and cyber cities development in the five (5) proposed development corridors.

Figure 2.1: Evolution of Sustainable Development and Urban Population from 1960-2020 in Malaysia

*Source: (Simson J., Ho, Matsuoka, & Gomi, 2011b)*
National Physical Plan 2025 (Federal Department of Town & Country Planning, 2010) and National Urbanization Plan (Federal Dept. of Town & Country Planning, 2006) provide comprehensive strategic spatial policies on the physical development and conservation. Both plans provide fundamental framework for the creation of Malaysian cities that promotes livable communities and sustainable development. Eight (8) themes are spelt out enhancing the national planning through spatial dimension in the country economic policies, namely;

1) Shaping national spatial framework,
2) Improvement of national economic competitiveness,
3) Modernization of agricultural sector,
4) Strengthen of tourism development,
5) Management of human settlement,
6) Conservation of wildlife and natural resources,
7) Integration of all national transportation network and
8) Installation of appropriate infrastructure (NPP 2006).

Malaysia has always advocated sustainable development, taking into the consideration of socio economic development and environmental protection in all the development planning projects (Ministry of Natural Resource & Environment Malaysia, 2009). Malaysia aims to attain a developed nation status under the vision 2020. The Vision 2020 was introduced in 1991 during the tabling of Sixth Malaysia Plan (1991-95) that aims to achieve a self sufficient industrialized nation by the year 2020. It encompasses not only the economic prosperity but also social well being, educational, technological progress and political goal. Development planning policies in mid 1990s focused on mega projects and major township development such as Putrajaya and Cyberjaya to spearhead economic development and utilizing smart infrastructure and state of technology development. All these projects are planned with sustainable development principles without direct target setting to reduce carbon emission.

However, Malaysia at the United Nations Climate Change Conference in 2009 during the 15th Conference of Parties (COP15) announced the intention of voluntary reduction up to 40% in terms of emission intensity of GDP by the year 2020 compared to 2005 levels. This voluntary commitment has made government machinery especially the regional and local planning authorities to interpret this target into their urban development vision. Figure 2.1 shows the evolution of sustainable development and urban population from 1960-2020.
2.2 **Review of Climate Change Policy in Malaysia**

Following the commitment to reduce emission intensity up to 40% by year 2020, The National Policy of Climate Change (NPCC) (Ministry of Energy, Green Technology & Water, 2009) was introduced. This NPCC highlights five (5) key principals as a national response that consolidates economy, social and environmental development. These principals are as seen in Figure 2.2.

![Figure 2.2: Principles of the National Policy on Climate Change.](source)

**P1: Development on a Sustainable Path**  
- Integrate climate change responses into national development plans to fulfil the county’s aspiration for sustainable development

**P2: Conservation of Environment and Natural Resources**  
- Strengthen implementation of climate change actions that contribute to environmental conservation and sustainable use of natural resources

**P3: Coordinated Implementation**  
- Incorporate climate change considerations into implementation of development programmes at all levels

**P4: Effective Participation**  
- Improve participation of stakeholders and major groups for effective implementation of climate change responses

**P5: Common but differentiated Responsibilities and Respective Capabilities**  
- International involvement on climate change will be based on the principle of common but differentiated responsibilities and respective capabilities

Malaysia begun implementing its road roadmap and these initiatives taken up by the urban development such as Iskandar Malaysia regional authority (IRDA) and two designated cities under Ministry of Energy, Green Technology and Water i.e. Putrajaya and Cyberjaya cities. These cities will be developed as pioneer townships in green technology as a showcase for the
development of other townships (KETTHA, 2009). Green technology shall be a driver to accelerate the national economy and promote sustainable development. The application of green technology will also help to minimize degradation to the environment by promoting zero or low GHG emission, the use of renewable resources in the urban area and also the government effort to combat climate change. In this paper, Iskandar Malaysia, one of the pioneer green low carbon urban developments in Malaysia will be used as a study case to understand the low carbon urban development in Malaysia.

2.3 **Review of Malaysia’s Energy Demand and CO₂ Emissions**

The 10th Malaysia Plan (2011-2015), outlined two major national policies on environmental protection and conservation i.e. National Green technology Policy (2009) and National Climate Change Policy (2009). The National Green Technology Policy emphasizes on sustainable development, development of roadmaps to guide the application of green technologies and also the establishment of Green Technology Financing scheme (GTFS). However, National Climate Change Policy will help to streamline and coordinate policy and legislation, stashed inter-ministerial and cross-sectoral committee to facilitate implementation and also to identify options and strategies to achieve low carbon economy (EPU, 2010).

Among the measures used in climate mitigation to reduce the carbon footprints are (a) creating incentives for investments in renewable energy (b) promoting energy efficiency to encourage productive use of energy (c) improving solid waste management (d) conserving forests and (e) reducing emissions to improve air quality. Under the incentives for investments in Renewable energy, the total renewable energy will be increase from <1% or 41.5MW to 5.5% of the total generated electricity or 985 MW by 2015.

With Reference to the Second National Communication Report (2NCR) 2011 to the United Nation Framework Convention on Climate Change (UNFCCC), the current scenario of Energy Demand and CO₂ emissions can be identified. The major proportion of commercial energy supply in 2000 and 2007 comes from oil and gas; 90.9% and 83.3% respectively, the other source of energy supply comes from Hydropower and Coke & coal. Table 2.1 shows the sector the trend of energy demand; Transport sector marks the highest energy demand in 1990 with
5,387ktoe however in 2007 the highest energy demand is from Industrial sector which is 19,116ktoe. These two sectors are the key contributors towards the CO₂ emission in Malaysia.

Table 2.1: Malaysian Final Energy Demand by Sectors (ktoe)

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>-</td>
<td>446</td>
<td>104</td>
<td>101</td>
<td>258</td>
<td>281</td>
</tr>
<tr>
<td>Non-Energy</td>
<td>908</td>
<td>2,994</td>
<td>2,250</td>
<td>2,173</td>
<td>2,809</td>
<td>2,958</td>
</tr>
<tr>
<td>Residential &amp; Commercial</td>
<td>1,646</td>
<td>2,837</td>
<td>3,868</td>
<td>5,134</td>
<td>5,430</td>
<td>6,196</td>
</tr>
<tr>
<td>Transport</td>
<td>5,387</td>
<td>7,827</td>
<td>12,071</td>
<td>15,384</td>
<td>14,825</td>
<td>15,717</td>
</tr>
<tr>
<td>Industrial</td>
<td>5,276</td>
<td>8,060</td>
<td>11,406</td>
<td>15,492</td>
<td>17,002</td>
<td>19,116</td>
</tr>
<tr>
<td>Total</td>
<td>13,217</td>
<td>22,164</td>
<td>29,699</td>
<td>38,284</td>
<td>40,324</td>
<td>44,268</td>
</tr>
</tbody>
</table>

Source: 2nd National Communication Report 2011

Figure 2.3 shows the Source of CO₂ emission in Malaysia, a total of 167.44Mton of CO₂ was emitted. Emission from energy industries has the highest emission with 58.48Mton CO₂; this is from industries who are the power and auto producers (self energy producers) for producing electricity, petroleum refining and natural gas transformation. However, second highest emitters are the transportation sector, and is followed by the Manufacturing industries construction.

Figure 2.3: Source of CO₂ Emission in Malaysia 2000

Source: 2nd National Communication Report 2011
The calculation done for analysis in the 2NCR reflects LEAP modeling. The National population is estimated to reach 32.76 million by year 2020, and the GDP is expected to grow at a slower rate of about 4.9% per annum for the period of 2000-2020. The estimation for the final energy demand for 2000-2020 can be seen in Figure 2.4. The Industrial and Transportation sectors show an average annual growth rate of 5.0% and 4.7% each respectively. In the energy sector there are three mitigation measures scenarios introduced, namely: The Energy Efficient Conservation (EEC), The Renewable Energy (RE) and the Total Combination of Assumptions (EEC+RE). The CO$_2$ emission under BaU scenario is expected to grow annually at about 3.72% from 2000 to 2020, Figure 2.5. In the EEC Scenario the growth will be at 3.53%, the RE scenario indicates a 3.49% annual growth. In the scenario which combines EEC and RE, the CO$_2$ emission will be the least which is about 243 million tonne CO$_2$ emission.

Figure 2.4: Final Energy Demand by Sectors in BaU Scenario, 2000-2020

Source: 2$^{nd}$ National Communication Report 2011
Figure 2.5: CO₂ Emission Projection by Scenarios, 2000-2020

Source: 2nd National Communication Report 2011

Malaysia has adopted positive steps to contribute to the global effort to fight global warming by developing a roadmap for climate resilient growth and enhancing conservation of the nations of ecological assets. Table 2.2 shows world average CO₂ emission was 6.7 tons per capita in 2007. This national average is higher than the world average of 4.35 tons per capita in 2007. The average emission intensity of 1.3 tonne of CO₂ per US$1000 of GDP is also higher than the world average of 0.73 tonne of CO₂ per US$1000 of GDP.

Table 2.2: CO₂ emission per capita and emission intensity of selected countries, 2007

<table>
<thead>
<tr>
<th>Countries</th>
<th>Emission per capita</th>
<th>Emission Intensity tones of CO₂ per US$1000 of GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>4.35</td>
<td>0.73</td>
</tr>
<tr>
<td>United States</td>
<td>19.1</td>
<td>0.5</td>
</tr>
<tr>
<td>Singapore</td>
<td>9.8</td>
<td>0.3</td>
</tr>
<tr>
<td>Japan</td>
<td>9.7</td>
<td>0.2</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>8.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Malaysia</td>
<td>6.7</td>
<td>1.3</td>
</tr>
<tr>
<td>China</td>
<td>4.6</td>
<td>2.5</td>
</tr>
<tr>
<td>Thailand</td>
<td>3.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1.7</td>
<td>1.6</td>
</tr>
<tr>
<td>India</td>
<td>1.2</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Source: 10th Malaysian Plan (2011-2015)
In the recent COP15, Malaysia government has pledged a voluntary 40% reduction of CO$_2$ emission intensity by 2020. Under the Tenth Malaysia Plan (2011-2015), government has intensified effort to reduce emission by climate adaptation and mitigation measures. In addition, major efforts towards a high income economy will also contribute to the fall of emission intensity by the year 2020.

2.4 What is a Low Carbon Society?

Japan has defined a Low Carbon Society as a society which should (Skea & Nishioka, 2008):

1) Take actions that are compatible with the principles of sustainable development, ensuring that the development needs of all groups within a society are met.
2) To make an equitable contribution towards the global effort to stabilize the atmospheric concentration of CO$_2$ and other greenhouse gases (GHG) at a level that will avoid dangerous climate change, through deep cuts in global emissions.
3) Demonstrate a high level of energy efficiency and use low-carbon energy sources and production technologies.
4) Adopt patterns of consumption and behaviour that are consistent with low levels of GHG emission.

Japan has been a pioneer in the Low Carbon Arena together with other developed nations such as United Kingdom and countries Germany. With the background in climate change and all its effects, many developing countries have now jumped in this bandwagon towards developing a Low Carbon Society. Malaysia likewise is moving in this same direction and it is the objective of this thesis research to develop a methodology where Low Carbon Society Policies can be implemented at Local Authorities level in Malaysia.
2.5 Reference for Chapter 2


3 METHODOLOGY

Based on the background and information given in the first two chapters; chapter three will present the entire image of methodology which will be used in this thesis to implement Low Carbon Society (LCS) in Local Authorities in Malaysia.

3.1 General Framework

This research presents a study of the structure Low Carbon Society (LCS) and how it can be introduced in a region or a city in Malaysia through the implementation of LCS policies. Figure 3.1 is the general structure flow of the methodology which can be used by a Local Authority towards the implementation of a LCS.

This methodology has been applied to two case studies in Malaysia; namely, (i) Iskandar Regional Development Authority (IRDA) and (ii) Putrajaya Corporation (PJC). This will be further explained in chapters four and five.

The framework of the methodology is as seen in Figure 3.1. It consists of fourteen (14) steps. The three main sections in this methodology can be identified as:

i. Quantification Methodology

ii. Implementation Methodology

iii. Input of Tools

The structure of the methodology which consists of fourteen steps is described with detail as follows:
(1) Form alliance with Local Authority.

This is the first step in the flow of this methodology; the researcher is to identify a study location (city, region, or nation) which is proposed for the implementation of Low Carbon Society (LCS). Once the location is identified, the researcher or team of researchers should approach the Local authority of that specific area. It is important for this alliance to be made. This will be the way the researchers and decision makers can have a relationship that enables them to share information and discuss the future plans of the city or region and move towards the implementation of Low Carbon Society (LCS) measures and policies in the future.

(2) Form a Project team

Next a project team which consists of researchers and task force is formed. This team of researchers will consist of members from the local authority together with members from the academia field. And the task force will be members of academicians from the higher level and decision makers from the Local Authority (LA).

3.2 Quantification Methodology

The quantification methodology consists of steps three and four:

(3) Design the framework of research

The framework for this research is mainly set once the project team is formed. This will be when both the researchers and the members from the local authority sit together to design the framework of this research. The objective of the research and the title of the project will be set and a time line for this research will be identified. During this step the available data for this research is identified by the researcher and measures are taken by the task force members to obtain these data from the relevant source.
(4) Projection of Socio-economic scenarios

During this step the Carbon Dioxide (CO$_2$) levels and the energy demand in the study area is identified. Quantification tools such as relevant socio-economic scenario calculation tools are used here. A more detailed explanation of the Methodology used here is discussed in Section 3.4 and Section 3.4.2 of this Thesis.

(5) Designate duty or role of project team

This is step taken by the project leader to designate the duty or roles of each of the team members. This is an important step when each member in the project team is designated with their duties during the course of the project.

3.3 Implementation Methodology

Implementation methodology consist of steps six to fourteen. This section is when the socio-economic quantification are analysed and discussed and presented to the decision makers.

(6) Focus Group Discussion I (FGD I)

Focus Group Discussion is discussed more in depth in section 3.5.2. FGD I is an Implementation Tool which is used here. However if this FGD I session is not successful, the team has to go back to step (3) and restart with the design of framework of the research. If the FGD I session is a success the members can proceed to step 7.

(7) Revise step four (4) with feedback from step six (6)

When the FGD I is conducted the feedback from this will enable the researchers to re-run the quantification tools. This will enable the research to come out with the emission estimation for the research area. From then forth, the team will prepare a list of Counter measures and actions which can be introduced in the study area to reduce the CO$_2$ emissions.
(8) Focus Group Discussion II (FGD II)

Focus Group Discussion II is discussed with more in depth in section 3.5.3. However if this FGD II session is not successful, the team has to go back to step (7). Only if this FGD II session is successful can the team move to step 9.

(9) Revise results based on FGD II

Based on the one or two day session of the FGD II, the researcher in the team will have a discussion and make reviews to the results in the emission reduction. And a list of how much emission can be reduced by each counter measure or action should be identified and calculated.

(10) Present output from FGDs and Modelling to Local Authority (L.A)

Once the results of emission reduction are identified, and the counter measures that need to be taken are outlined. The project team will prepare a presentation and documents which will be presented to the LA involved. This will be an informal presentation where there should be a lot of interaction between the team members and feedback from the LA.

(11) Revise Output based on Comments

The revision to the emission reduction calculation, actions and counter measures are then revised according to the feedback from the LA.
1. Form an alliance with Local Authority (L.A)
2. Form a project team
3. Design the framework of research
   - Set project Name, Set objectives & Set time line
4. Projection of Socio-economic scenarios
   - Estimation of energy demand & CO₂ emission levels
5. Designate duty/role of project team
6. Focus Group Discussion I (FGD I)
7. Revise Step 4 with feedback from Step 6
8. Focus Group Discussion II (FGD II)
9. Revise results based on FGD II
10. Present output from FGDs and Modelling to LA
11. Revise Output Based on Comments.
    - Present the final output to the board members LA
13. LA Introduces Low Carbon Measures/Actions & Implement it as Policies
14. Determine the Success
   - This can only be determined when these LCS policies are implemented for a period of time based on Target Year set.
   - Possibly an emission reduction accounting system can be introduced in the future.

Figure 3.1: Methodology of Low Carbon Society Development
(12) **Prepare Brochure & Technical Report**

Once all details of the results are agreed by both the project team and the decision makers in the LA, materials for publicity are produced. Materials such as brochures and leaflets to introduce the LCS actions and measures are created and published. A technical report with all the detail calculations and measures taken during the research project should be recorded for future reference.

(13) **Local Authority Introduces Low Carbon Measures/ Actions and Implement it as Policies**

The LA will then implement the proposed actions one by one in their local area. This will bring both good and bad feedback from the public. This will also need to be monitored by the LA so that it will be helpful for future studies. Once an action is successful in the implementation procedure, the LA will then make efforts to introduce it as a policy.

(14) **Determine the success.**

To be able to determine the success of this project, it is only possible to be done maybe after about five years from the start of the implementation of LCS measures. This will also need an emission reduction accounting system to be introduced for the calculation of emission reduction. These are the steps involved in the methodology towards developing a Low Carbon Society Development.
3.4 ** Quantification Tools

3.4.1 **The Extended Snapshot tool (ExSS)**

A fixed quantity used for this process is the estimation tool: "ExSS (Extended Snapshot tool)."

The outline of the estimation system of a snapshot tool is shown in Figure 3.2. The main function and features of this tool is as mentioned below:

EXSS (extended snapshot tool) is a comprehensive calculation tool developed to;

- Illustrate quantitative future snapshot of a city/region, especially as a low-carbon society,
- Analyze relationship of socio-economic conditions and environmental load emissions, and
- Define a portfolio of the measures to meet environmental target (mainly energy-oriented CO$_2$).

This tool estimates,

- Socio-economic activity level of the sectors in future,
- Environmental load emissions, and
- Counter measures necessary to achieve the target.

Features of this model are as follows.

- A static model formulated as a set of simultaneous equations.
- Input-output analysis is the central part in the computation system.
- IO relation is described in detail especially generation of freight and passenger transport and energy demand and supply structure.
3.4.2 The Community Extended Snapshot tool (C-ExSS)

Community Extended Snapshot Tool (C-ExSS) is an estimation tool to design low-carbon society. This tool illustrates the quantitative future snapshot of the community, and estimates the future environmental load of emissions. C-ExSS is an estimation tool which is used in calculations for low-carbon society in communities or towns which do not have large industrial sector. It illustrates the quantitative future snapshot of the city including energy demand, CO₂ emissions and a portfolio of measures to meet the low-carbon target. The features of C-ExSS are:

i. It is a multi-sector static model. The sectors in this study are: Commercial, Public amenities & facilities, Government departments and Residential.

ii. The household sector is classified by income classes, so it is possible to consider household structure change.

iii. The energy demand is driven by population, floor area and the number of employment.
This tool runs on Microsoft Excel. C-ExSS can be run in the Excel file which consists of many worksheets. The flow chart showing the structure of C-ExSS is seen in Figure 3.3. The details of this Model structure are attached to Appendix.

![Figure 3.3: Structure of C-ExSS](image)

The steps for calculation in the C-ExSS tool are as seen in the Figure 3.4. The first step is to set the target region, base year, estimation case and to identify the units in which these calculators will be calculated in. The second step involves the input of the base year data. The base year for the Putrajaya Green City 2025 study is set at 2007 based on the availability of data and information. In this step the CO₂ emissions in the base year is calculated. The third step is when the CO₂ emission for the future (target year) is estimated. The target year is set as 2025. The Low carbon counter measures are set in the following step and also the abatement cost can be
calculated in this level. The fifth and final step is to analyze the results. Identify the factor of reduction of each emission reduction either by sector or by actions.

Figure 3.4: The Calculation Procedure in C-ExSS

3.5 Implementation Tools

3.5.1 Focus Group Discussions (FGD)
Focus group discussions (FGD) is a rapid assessment, semi-structured data gathering method in which a purposively selected set of participants gather to discuss issues and concerns based on a list of key themes drawn up by the researcher/ facilitator (Escalda & Hong, 2007). FGD goes back to the 1920’s when it was a method of inquiry used during the after World War II period to study the persuasiveness of propaganda. This method has increasingly become a popular qualitative methodology among market researchers, social scientists, public opinion pollsters,
industrial psychologist, political campaign managers, anthropologist and other qualitative researchers (Federal Dept. of Town & Country Planning, 2009).

The implementation of Low Carbon Society actions or policies involves the role and participation of the general public, government sector, private sector, Non-governmental agencies, Public Service Departments and various other stakeholders. Since this involves the public alongside the governance, it is important to have a guideline as to how the meeting or discussion session needs to be undertaken. Why is the public opinion and feedback an important entity when implementing LCS policies in a LA? Below listed are a just a few example in reasons:

i. The public have a right to be informed on the direction the Local Authority or Government is taking with regards

ii. LCS actions begins with the change of human behavior, therefore it is important for people to know why they need to change their behavior and lifestyle.

iii. The comments from the public are important and must be taken into account because they are also participants in the Local Authorities agenda and activity.

iv. Sometimes input from the public may help avoid costly environmental disputes or mistakes.

For this thesis research, FGD is used to bring together the academic world of research to the real world arena in Local Authorities where decisions are made every day. The Socio-economic modeling tools which are used to determine the CO2 emission levels in a city or region. And these numbers are quantified into the proposal of mitigation measures which will assist in lowering the emission levels. This is when the FGD is needed; to get opinion and feedback from the Local Authority and the various stake holders who are involved in the planning and development of a city. This is because when a policy needs to be made, the general public will be the persons directly facing the challenges faced to uphold to the policy requirements. The Methodology as to how FGD is carried out in Putrajaya and Iskandar Malaysia are discussed in the following two chapters of this thesis.
3.5.2 Methodology of Implementation of Focus Group Discussions I (FGD I)

The Methodology used when implementing a Focus Group Discussion I (FGD I) during the development of LCS in a city or region is as seen in Figure 3.5. This steps that need to be taken are divided into three main categories:

a. Preparations before the FGD I session (Steps one (1) to six (6))

b. During the FGD I Sessions (Steps seven (7) to ten (10))

c. After the FGD I Session. (Step 11)

There are eleven steps in this FGD (Phase I). Each step requires detailed and precise actions that need to be taken by each of the project team members so that the FGD I Session runs smoothly. In Category (a), these are the steps that need to be taken:

(1) Identify the Issues and current status of Research.

The objective of having this FGD need to be identified at this stage. The team needs to set the Base year and the Target year so that the relevant data can be obtained from the relevant agencies and departments during the FGD. A list of data’s which might me required for this research is to be prepared so that it can be shared with the participants and they will be able to help with the obtaining of these data’s.

(2) Form a task force for the FGD

A task force needs to be put into place and named. The main persons who will be moderating or facilitating the FGD should be identified. A briefing session should be held for the facilitators if there is more than one facilitator involved.

Persons who will be the recording secretaries during the FGD should be identified so that they can prepare to take minutes and notes during these sessions. It is important to have about two or three persons as recording secretaries when the group is about 50 persons in number. This will be a measure to ensure no message and data is missed.

(3) Identify and Invite the Participants

This will be task of the Local Authority, they will have to identify the relevant departments who will be able to contribute towards this study and send out invitations to these persons.
(4) Have Internal discussion

Internal discussions between the project team members and the organizing committee in the LA should be held so that there will a good understanding about the flow of events during the FGD. An agenda for the FGD I session should also be prepared.

(5) Set the venue for FGD

Usually the FGD I is an internal event. Held between the various departments in the Local Authority. Therefore it is usually held in the vicinity of the LA. However if this needs to be done outside the LA, the costing budget should be taken into account by the sponsor of this project.

(6) Costing for the FGD session

The project team should identify who the financial sponsor for this research is. And a budget for this event needs to be prepared and sent to the sponsor so that there will not be any monetary issues arising later in the project.

![FGD (Phase I)](image)

**Preparations Before the FGD Sessions**

- **FGD (Phase I)**
  - (1) Identify the issues and current status
    - Prepare all relevant data and information for the FGD session.
    - Base year & target year data.
    - Identify what data is unavailable.
  - (2) Form a task force for the FGD
    - Identify moderators who will facilitate the session.
    - Task: Prepare, manage, coordinate, and records the FGD
  - (3) Identify & invite participants
    - Participants from LA & Government Agencies.
  - (4) Have Internal Discussion
    - Between Task Force Members and Key persons from LA
    - Identify and set the agenda for FGD session.
    - Prepare
  - (5) Set the venue for FGD
    - Prepare a budget for the session. Including food, stationeries', and others.
  - (6) Costing for FGD Session

**During the FGD Sessions**

- **Set Objectives and format of discussions**
  - Set rules so that the discussion runs according to topic
  - Moderator to monitor each group.
- **Discussion & Brainstorming Time**
  - Set time for discussion (2-2.5 hours)
  - Each group to have recording secretary to take notes.
- **Presentation of Results by Each Group**
  - Prepare outcome of discussions to be shared with All groups/ main group.
- **Identify the Overall conclusion**
  - The conclusion should meet the objective of the FGD.
- **Final Report**
  - The Task Force – gather all the presentations and identify issues that have been discussed
  - Interprets the findings
  - Prepare Report & Brochure

**Figure 3.5: Structure of Focus Group Discussion I**
Category (b) of this session involves steps that need to be taken during the FGD I session. These involve:

(7) Set Objectives and format of discussion
The objective of the FGD as decided in step one has to be conveyed to all the participants. The facilitator of the session and team should make sure the FGD session stays in focus of the objective and does not go out of topic.

(8) Discussion & Brainstorming Time
Participants are divided into smaller groups if there are too many participants from a variety of field specialty. There should be a specific time limit set for discussion within groups. This session may go on from one to two hours. However each group should have a recording secretary.

(9) Presentation of Results by Each Group
Each team will be required to present the results of their discussion in a short five to seven minute presentation. And the recording secretary has to present the report to the project team members.

(10) Identify the Overall Conclusion
The FGD I session moderator should conclude the session and make sure the objectives of this FGD I are met.

(11) Final Report
The Project team members will prepare a document which will be a record of all that was discussed and gathered during this FGD I. This sometimes will be in either a form of memo or a leaflet which can be used during the next FGD II.

3.5.3 Methodology of Implementation of Focus Group Discussions II (FGD II)

The Focus Group Discussion II session steps are as seen in Figure 3.6. This FGD II is also divided into three main categories.
Figure 3.6: Structure of Focus Group Discussion II

There are all together eleven steps in this FGD II. They are divided into three main categories:

a. Preparations before the FDG I session (Steps one (1) to six (6))
b. During the FGD I Sessions (Steps seven (7) to ten (10))
c. After the FGD I Session. (Step 11)

(1) Prepare the materials for this session
The task force and researchers have to prepare the relevant materials from FGD I and also the socio-economic estimation calculations done by the modeling tools.

(2) Have Internal Discussion
Internal discussions between the project team members and the organizing committee in the LA should be held so that there will a good understanding about the flow of events. An agenda for the FGD II session should also be prepared.

(3) Identify Function of Task force
The task force has to consist of facilitators, moderators and recording secretaries during the FGD II. These roles have to be delegated to the respective persons. There should also be a chairperson
who will conduct and co-ordinate the whole event, since there will be many presentation session during the latter half of the FGD II event.

(4) Identify and Invite the Participants
This will be task of the Local Authority; they will have to identify the relevant departments, government officers, private companies, Non-governmental organizations, residents and other stakeholders who will be able to contribute towards this study. Invitations need to be sent out at least a month in advance from the date of the FGD II event.

(5) Set the venue for FGD
Usually the FGD II is an external event. It is held between the various government departments and stakeholders. Therefore it is can either be held in the vicinity of the LA or outside in a hotel or a private venue. However if this needs to be done outside the LA, the costing budget should be taken into account by the sponsor of this project.

(6) Costing for the FGD session
The project team should identify who the financial sponsor for this research is. And a budget for this event needs to be prepared and sent to the sponsor so that there will not be any monetary issues arising later in the project.

Category (b) of the FGD II is the steps during the FGD II session. This is a held for duration of two days or more depending on the issues that need to be discussed. Below listed are the steps held on:

Event on Day one:

(7) Register Participants
It is the task of the task force for the FGD II to make sure all the participants who attend this event are registered. This is important because all these participants will then be divided into
groups according to their field of specialty or according to field of study. Participants will be divided into groups of 5-10 persons per group.

(8) Presentation by Main Speakers

The main speakers will be from either the Project Team or invited professional speakers on the respected field according to the objective of the FGD II. The Project Team will have to present about the findings in FGD I and the continuation from there forth. This is when the Participants will be introduced to Low Carbon Counter measures and Low Carbon Actions. It is an important session to make the Participants understand their task during the group discussion sessions.

(9) Break into Group Discussion

The participants are divided into their respective groups according to the registration session in step (7). Following this, the discussion session would require the Participants to come out with actions, sub-actions and programs which the Local Authority (LA) can introduce towards lowering CO2 emission and leading a Low Carbon Society lifestyle. The groups are given about four hours to discuss and come out with a list of sustainable and suitable results.

Event on day two

(10) Final Group Presentation

Each group will have the first two hours of day two to compile all that they have discussed during the session in Day one. Following this each group will have to present their results. Each team will have about 20-30 minutes to present. The time limit will depend on the number of persons and time allocation.

The final step will be under category (c) which is done after the FGD II.
Final Report for Policy guideline

The project team which should compile all that has been done in FGD II and FGD I. This has to be presented in a form of Technical Report and a brochure. This has to be a guide for policy makers.

These are all that needs to be done during the Focus Group Discussion (FGD) I and II.

3.6 Reference for Chapter 3


4 THE CASE STUDY OF ISKANDAR MALAYSIA

4.1 Introduction to Iskandar Malaysia

The Iskandar Malaysia (IM) area covers about 2,216.3km$^2$, it is about three times the size of Singapore and two times the size of Seoul Metropolitan Area. IM covers the entire district of Johor Bahru, and several sub-districts of Pontian. 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.

Iskandar Malaysia lies at the heart of South East Asia at the southern tip of Peninsular Malaysia and within minutes from Singapore. It is strategically located at the major cross roads of East-West trade routes of fast growing countries like China and India. From a regional perspective, the development of Iskandar will lend a greater competitive edge to the region and will benefit

![Figure 4.1: The Flagship Zones within Iskandar Malaysia](image)

*Source: Iskandar Regional Development Authority.*
significantly from the air and sea linkages within Asia-Pacific countries. There are a total of five flagship zones (Figure 5) proposed as key focal points for development within the IM area.

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.

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 policies are energy efficient building, sustainable land use and transportation, and natural and green environment.

4.2 Background of Low Carbon City- Sustainable Iskandar Malaysia 2025

This research project which is conducted in the area under the governance of Iskandar Regional Development Authority (IRDA) is a joint effort between many both Malaysian and Japanese counterparts. This is a large project team involving these agencies and universities:

- Kyoto University
- Okayama University
- National Institute for Environmental Studies (NIES)
- University Teknologi Malaysia (UTM)
Each department and agency has its representative members who run this project. The main aim of this research project was to first identify and present the current levels of CO\textsubscript{2} emission in Iskandar Malaysia. In accordance to this, measures required to reduce the per capita CO\textsubscript{2} emission from fuel combustion by 30% by 2025CM against the levels of 2005 and to reduce 50% of CO\textsubscript{2} emission by introducing counter measures (CM) in year 2025CM from 2025BaU Business as Usual scenario.
4.3 Methodology of Implementing Low Carbon Society in Iskandar Malaysia

Figure 4.2: Methodology for developing a LCS for Iskandar Malaysia
The methodology for developing a Low Carbon Society (LCS) for IRDA is as seen in Figure 4.2. This methodology structure is an adaptation of the LCS development structure introduced in Chapter 3 (Figure 3.1). However each step as mentioned in this flow chart is custom-made to suit the development in IM.

In the case of research implementation in Iskandar Malaysia, the Quantification Methodology is the only section which has been successfully completed in this study. The stages in Implementation Methodology will be continued in the future. The implementation section of this methodology was not able to be completed because Iskandar Malaysia consists of five different local authorities and more than 150 other stakeholders. Conducting Focus Group discussions in IM will take a long time compared to the study area of Putrajaya. However, this research did produce a brochure which describes the results from the quantification tool and methodology. The target of lowering the CO\textsubscript{2} emission in Iskandar Malaysia and the calculation methods will be discussed in the following sections. The results from this case study was also presented to Iskandar Regional Development Authority (IRDA).

4.4 **Quantification Methodology for Iskandar Malaysia**

4.4.1 **Design the Framework of Research**

The outline of the problem establishment of Low Carbon Society (LCS) research is shown in Figure 4.3. In this study, the socioeconomic assumption of the target year, environmental load emissions, and measures for reduction are collectively called "future society image." This is the first half of the backcasting technique; the suitable and concrete kind of action which needs to be taken in the areas can be identified, by comparing the future society’s image with the present condition. The method of achieving the environmental target is very important in the LCS study.
Therefore, "socioeconomic assumption" is the principle idea. It is a view that such an environmental program is needed when a socioeconomic assumption is given.

Present condition

Future society image

Socioeconomic assumption
- Consumption contents
- Population composition
- Industrial structure
- Economic growth
- Land use
- Transport demand

Environmental load emissions
- Required measures

When an assumption are given...

These things to be obtained

**Figure 4.3: Outline of the problem establishment of LCS study**

*Source:* (Gomi, Ochi, & Matsuoka, 2011)

### 4.4.2 Overview of the procedure

The procedure of the methodology used for this research is shown in Figure 4.4. For quantification of socioeconomic assumptions, a setup of measures in a target year, and the estimation of a target year are made, and the below-mentioned fixed-quantity estimation tool (Extended Snapshot tool; ExSS) is used.

1. Setting the framework

First, the framework of the whole low-carbon society scenario creation is decided. This comprises of the coverage area, a base year, a target year, target activity, an environmental target, the number of scenarios, and etc. It is thought that it is desirable that it is long to such an extent that a required change is realizable, and it is near to such an extent that people of the area can imagine as for a target year.
(2) Description of socioeconomic assumptions (qualitative scenario description)

Before performing quantitative estimation, a qualitative future image has to be described. The descriptions are such as a change in lifestyle, industry, and land use. Below listed are some of the ways used to find descriptions when describing a qualitative future image of a society.

i. Use an existing conceptual plan, development plan, or a set target for the existing each field of the area,

ii. Interview a well-informed person in the LA or organize a workshop, etc.,

iii. Extend or fix the present condition simply,

iv. Documents or plans about the future of a country or a bigger area than can be considered.

In consideration of an actual measure process, it is necessary to choose the method of being more meaningful in deployment of a subsequent policy. Moreover, assumption of social economy is the "premise" of low-carbon society construction to the last. Therefore, in this study, the method of realizing assumption (for example, growth rate of a certain industry) for a certain socioeconomic assumption is not referred.
(3) Quantification of socioeconomic assumptions

In order to estimate the future image based on the assumption as mentioned in step (ii), set up the value of the index shown in Table 4.1. These are fitted into the ExSS as exogenous variables or a parameter. Socioeconomic assumption is considered to have big influence especially to GHG emissions; it is an economic growth rate of the whole country, export value by industry, population arrangement, and a labor-force participation ratio.

<table>
<thead>
<tr>
<th>Index</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population composition ratio</td>
<td>Population composition ratio by sex and age cohort</td>
</tr>
<tr>
<td>Average number of household members</td>
<td>Average number per household</td>
</tr>
<tr>
<td>Labor-force participation ratio</td>
<td>Labor-force participation ratio by sex and age cohort</td>
</tr>
<tr>
<td>Export value</td>
<td>Demand of goods and service from other areas by industrial classification</td>
</tr>
<tr>
<td>Import rate</td>
<td>Rate supplied from industry outside the area among the demand of goods and service within the area</td>
</tr>
<tr>
<td>Government expenditure</td>
<td>Government consumption expenditure, government fixed capital formation</td>
</tr>
<tr>
<td>Input coefficient</td>
<td>Input coefficient matrix for input-output analysis</td>
</tr>
<tr>
<td>Labor productivity</td>
<td>Labor force required per output</td>
</tr>
<tr>
<td>Commuting OD (origin &amp; destination)</td>
<td>Percentage of the worker by working region and permanent residence place</td>
</tr>
</tbody>
</table>

(4) Collection of low-carbon measures

Measures considered feasible to be introduced for a target year are collected. It can be considered that In addition to energy-saving technology, change of traffic structure, renewable energy, energy-saving action, the source of absorption, etc. can be considered.

(5) Setting introduction of measures in the target year

Set up the amount of introduction of the collected measures as mentioned in step (iv) and decide the value of the technical coefficients (energy efficiency etc.) of energy demand and GHG
emissions. As a standard for determining the combination of a measure, standards, minimization of expense, receptiveness to a stakeholder, and technical feasibility can be considered.

(6) Estimation of GHG emissions in the target year

Input the value of the exogenous variables set up in step (iii) and (v), and a parameter, and estimate a social economy index and the amount of GHG emissions. Socioeconomic indicators are population, value added of the area, output by industry, transport demand, etc. If the amount of GHG emissions attains the target, it will progress to step (vii). If not attained, it returns to step (v) and the amount of introduction of an environmental measures is reexamined.

(7) Confirming measures set and suggestion of policy recommendations

Since ExSS calculates the amount of GHG emission reduction by measure, a measure especially with high reduction potential or the local government’s original policy can show the effect of the measure which becomes important. Propose the policy set for guiding the spread of the measures identified in step (vi).

4.4.3 Fixed-quantity estimation

Although the state of the society and economy of the area in a target year also influences GHG emissions greatly, the estimation of the amount of environmental pollutants requires information quantitative about socioeconomic activity. For example, population, the value of production of industry, traffic, etc. In this study, these are called a "socioeconomic indicator." In this methodology, these values are estimated in fixed quantity using an estimation tool (snapshot tool). Since socioeconomic assumptions in a target year "should be given", from the original purpose, the contents are not the targets of study. Moreover, it hardly understands that it is certain about the socioeconomic condition of the existing area of the future tens of years after.
However, it is necessary to balance between activity conditions in every direction. When a close relationship between socioeconomic indicators (for example, population and traffic) and those values are set up without the relationship, there is a possibility of carrying out strange assumption. Therefore, the relationship between indicators is formulized and the consistent value is acquired by numerical computation.

A fixed quantity used for this process is the estimation tool: "ExSS (Extended Snapshot tool).” The outline of the estimation system of a snapshot tool is shown in Figure 4.5.

In this research for Iskandar Malaysia (IM), working-hours demand is used as a population determinant made into labor force demand, and the concept of time is not taken into consideration. Moreover, since it is easy at present, neither tax rates, social security contributions as a percentage of national income, other receipts of household economy (social security, property income, etc.), the existence of a driver's license, and the travel purpose of passenger transport, nor feedback of transportation and energy is taken into consideration.
4.4.4 Framework of Future Society Image Description

The first step in identifying the future society, we need to set the base year and the target year for this research:

**Base Year**: 2005; is set due to the availability of most of the data for Iskandar Malaysia area are from this year.

**Target Year**: 2025; is set because the Comprehensive Development Plan published by IRDA has a development plan target for IM and this is the time line set.

**GHG Emission Target**:
- 30% reduction of per capita CO\(_2\) emission from 2025BaU to 2025CM (with counter measure)
- 50% reduction of CO\(_2\) emission intensity from 2005 to 2025CM
Target Activity:
Residential sector, commercial sector, industry sector, passenger transport sector, and freight transport sector in the area. However, it is aimed at movement which leaves Iskandar Malaysia in the transportation sector.

Low-Carbon Measure:
The measure of a Shiga Prefecture Sustainable Society Research Team (2005) "Shiga’s scenario towards realization of sustainable society" is used as a benchmark, and the information on newer measure and technology was added to the research for IRDA.

4.5 Data collection and parameter estimation

The collection of the socioeconomic data of a base year and energy data for Iskandar Malaysia was carried out. The use of the data list on socioeconomic indicators is shown in the Appendix Table 1 and Table 2.

4.5.1 Energy balance & input-output table
The Energy Balance and Input-output (IO) table for Iskandar Malaysia are one of the most important data required. For this research these data are adapted from previous studies by (Yoshimoto, 2010). The list energy balance and IO table used are shown in Appendix Table.

4.5.2 Passenger transport
The structure of the passenger transport model and the parameter estimation of the base year of the model are explained in this section.
1) **Formulization of the passenger transport model**

The estimation formula of the passenger transport model is shown below. The annual passenger transport volume (passenger-km) is estimated by multiplying residential population (person) by the trip generation per person per day (trip/person/day), modal share, average trip distance (km/trip), and the days for one year (365 days).

\[
PTD_{ptm} = \sum_{sex} \sum_{age} Pop_{sex,age} \cdot PTG_{sex,age} \cdot PTS_{ptm} \cdot PTAD_{ptm} \cdot 365
\]  

(4-1)

Where,

- \(PTD_{ptm}\): passenger transport volume by mode (passenger-km)
- \(Pop_{age,sex}\): population by sex and age cohort (person)
- \(PTG_{sex,age}\): trip generation per person per day (trip/person/day)
- \(PTS_{ptm}\): modal share (passenger) (-)
- \(PTAD_{ptm}\): average trip distance by mode (passenger) (km/trip)
- \(sex\): sexuality (male, female)
- \(age\): age cohort (0-14, 15-64, 65+)

2) **Data complement**

Since the statistical information about the passenger transport in Iskandar Malaysia had not fully been obtained, the data about the passenger transport volume which runs short was complemented with the following ways using some assumptions.

i) **Passenger vehicle**

The passenger transport volume of the passenger vehicles (motorcars, motorcycles, and buses) was estimated using the formulas shown below. The reference data used for the complement of the passenger transport volume of motorcars is shown in Table 4.2.
[No. of passenger vehicles in IM (vehicle)]

= [No. of passenger vehicles in Malaysia (vehicle)]

* [No. of households in IM]/ [No. of households in Malaysia]  \[4-2\]

[Passenger transport volume (vehicle-km)]

= [No. of passenger vehicles in IM (vehicle)]

* [Annual mileage per vehicle (km/vehicle/year)]  \[4-3\]

[Passenger transport volume (passenger-km)]

= [Passenger transport volume (vehicle-km)]

* [No. of passengers carried by per vehicle per trip (person/vehicle/trip)]  \[4-4\]

<table>
<thead>
<tr>
<th>Mode</th>
<th>Annual mileage per vehicle (km/vehicle/year)</th>
<th>No. of passengers carried by transport per vehicle per trip (person/vehicle/trip)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorcar</td>
<td>10,000</td>
<td>1.89</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>10,000</td>
<td>1.65</td>
</tr>
<tr>
<td>Bus</td>
<td>40,000</td>
<td>18.75</td>
</tr>
</tbody>
</table>

- Annual mileage per vehicle

The value of Other Asia 2000 in Fulton and Eads (2004) is used for values of motorcars, motorcycles, and buses.

(Motorcars: p.33-34, Average travel per vehicle per year, Other Asia, data of 2000, Motorcycles: p.39, Year 2000 values for key parameters - 2 wheelers, Other Asia, data of Average travel per vehicle, Buses: p.61, Average annual travel per vehicle, Other Asia, data of 2000)
- No. of passengers carried by transport per vehicle per trip

The value of Other Asia 2000 in Fulton and Eads (2004) is used for values of motorcars, motorcycles, and buses. About buses, it was considered as the average value of large buses and small buses.

(Motorcars: p.35, Average LDV occupancy, Other Asia, data of 200, Motorcycles: p.39, Year 2000 values for key parameters - 2 wheelers, Other Asia, data of passenger km per year and vehicle km per year, Buses: p.59, Year 2000 Estimates for Large Buses & Small Buses, Other Asia, and data of Average passengers per vehicle)

ii) Passenger railway

The passenger transport volume of railways was estimated using the formula shown below.

\[
\text{[Passenger transport volume in IM (passenger-km)]} = \text{[Passenger transport volume in Malaysia (passenger-km)]} \quad (4-5)
\]

(No. of railways stations in IM: 7, No. of railways stations in Malaysia: 109)

3) Parameter estimation

i) Trip generation per person per day

Since trip generation per person per day of the passenger transport was not acquired the statistical information, the assumption 2.25 (trip/person/day) is used.

ii) Modal share

Since a person trip survey in Iskandar Malaysia did not exist, the modal share of the person trip survey in Kuala Lumpur was used as a reference value. However, about motor vehicles, the road traffic survey data in the region for Ministry of Works and Malaysia (2006)"Road Traffic Volume Malaysia2006" is used. And the values of motorcars, motorcycles, and buses were
changed among the modal shares in Kuala Lumpur. The result of the above-mentioned data complement is shown in Table 4.3

### Table 4.3: Modal share

<table>
<thead>
<tr>
<th></th>
<th>Railways</th>
<th>Bus</th>
<th>Motorcar</th>
<th>Motorcycle</th>
<th>Walk</th>
<th>Bicycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modal share</td>
<td>0.011</td>
<td>0.015</td>
<td>0.534</td>
<td>0.226</td>
<td>0.147</td>
<td>0.067</td>
</tr>
</tbody>
</table>

*Source: The Federal Territory Development and Klang Valley Planning Division et al., 1999*

### iii) Average trip distance

The average trip distance according to mode was found using the passenger transport volume (passenger-km) which was computed by complement estimation based on the formula 4.1, the modal share, the passenger transport source unit, and population. However, since the information about passenger transport volume of walk and bicycles was not acquired, average trip distances of walk and bicycles were assumed to be 1.0 km and 2.5 km, respectively. As a result, the values are shown in Table 4.4

### Table 4.4: Average trip distance

<table>
<thead>
<tr>
<th>Unit: km/trip</th>
<th>Railways</th>
<th>Bus</th>
<th>Motorcar</th>
<th>Motorcycle</th>
<th>Walk</th>
<th>Bicycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average trip distance</td>
<td>1.8</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>1.0</td>
<td>2.5</td>
</tr>
</tbody>
</table>

### 4) Discussion

The detailed data about the passenger transport in Iskandar Malaysia is not fully obtained. Therefore, since some assumption must be used, the reliability of data based on assumption is not so high. While advancing collection of the further statistical data from now on, the complement method of data needs to be improved.
4.5.3 Freight transport volume

The structure of the freight transport model and the parameter estimation of the base year of the model are explained in this section.

1) Formulization of the freight transport model

The estimation formula of freight transport volume is shown below. Freight transport volume (t-km) is estimated by multiplying output of industry (RM) by freight transport generation per output (t/RM), modal share, and average trip distance (km).

\[ FTD_{fm} = FTPD_{pss} \cdot FTG_{pss} \cdot FTS_{pss, fm} \cdot FTAD_{fm} \]  (4-6)

Where,

- \( FTD_{fm} \): freight transport volume by mode (t-km)
- \( FTPD_{pss} \): output of industry (primary and secondary industry) (RM)
- \( FTG_{pss} \): freight transport generation per output (t/RM)
- \( FTS_{pss, fm} \): modal share (freight) (-)
- \( FTAD_{fm} \): average trip distance by mode (freight) (km)

\( pss \): primary and secondary industry

2) Data complement

Since the statistical information about the freight transport in Iskandar Malaysia had not fully been obtained, the data about the freight transport volume which runs short was complemented with the following ways using some assumptions.

- Freight vehicles

The freight transport volume of freight vehicles was estimated using the formulas shown below. The reference data used for the complement of the freight transport volume of freight vehicles is shown in Table 4.5.
[No. of freight vehicles in IM (vehicle)]

= [No. of freight vehicles in Malaysia (vehicle)]

*[(output of industry in IM)/(output of industry in Malaysia)]

(4-7)

[Freight transport volume in IM (vehicle-km)]

= [No. of freight vehicles in IM (vehicles)]*[Annual mileage per vehicle (km/vehicle)]

(4-8)

[Freight transport volume in IM (t-km)]

= [Freight transport volume in IM (vehicle-km)]

*[Load tonnage per vehicle per trip (t/vehicle/trip)]

(4-9)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Annual mileage per vehicle (km/vehicle)</th>
<th>Load tonnage per vehicle per trip (t/vehicle/trip)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight vehicle</td>
<td>31,480</td>
<td>2.93</td>
</tr>
</tbody>
</table>

- Annual mileage per vehicle

Annual mileage per vehicle of a freight vehicle was weight averaged using average mileage of Medium-duty truck (20,000 km) and Heavy-duty truck (60,000 km) and the percentage distribution of Medium-duty truck (29%; 1,489,000 vehicles) and Heavy-duty truck (71%; 3,699,000 vehicles). These reference values were from Fulton and Eads (2004).

- Load tonnage per vehicle per trip

Load tonnage per vehicle per trip of a freight vehicle was weighted averaged using average load tonnage per vehicle per trip of Medium duty truck (1.7 t/vehicle) and Heavy-duty truck (6.0 t/vehicle) and the percentage distribution of Medium-duty truck (29%; 1,489,000 vehicles) and
Heavy-duty truck (71%; 3,699,000 vehicles). These reference values were from Fulton and Eads (2004).

- Freight railways

The passenger transport volume of railways was estimated using the formula shown below.

\[
\text{[Freight transport volume in IM (t-km)]} = \text{[Freight transport volume in IM (t-km)]}^* \times \left( \frac{\text{No. of railways stations in IM (KTM)}}{\text{No. of railways stations in Malaysia (KTM)}} \right) \quad (4-10)
\]

(No. of railways stations in IM: 7, No. of railways stations in Malaysia: 109)

3) Parameter estimation

i) Freight transport generation per output

Freight transport generation per output was computed by dividing the sum total value of freight transport volume by mode (tonnage) with the sum total value of output of primary industry and secondary industry. As a result, the value 703 (t/mil RM) was obtained.

ii) Modal share

The modal share in a freight transport was computed from the rate (t-km base) of each mode occupied to the sum total of freight transport volume. As a result, the value shown in Table 4.6 was acquired.

<table>
<thead>
<tr>
<th>Modal share</th>
<th>0.003</th>
<th>0.997</th>
</tr>
</thead>
</table>

Table 4.6: Modal share
iii) **Average trip distance by mode (freight)**

The average trip distance by mode was computed using the freight transport volume (t-km) which was computed by complement estimation based on the formula (2.42), modal share, freight transport generation per output, and output of industry (primary and secondary). As a result, the value shown in Table 4.7 was acquired.

<table>
<thead>
<tr>
<th>Table 4.7: Average trip distance by mode (freight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit: km</td>
</tr>
<tr>
<td>Average trip distance</td>
</tr>
</tbody>
</table>

4) **Discussion**

The detailed data about the freight transport in Iskandar Malaysia is not fully obtained. Therefore, since some assumption must be used, the reliability of data based on assumption is not so high. While advancing collection of the further statistical data from now on, the complement method of data needs to be improved.

4.5.4  **Parameter estimation of floor space of commercial buildings**

The structure of the floor space of commercial buildings model and the parameter estimation of the base year of the model are explained in this section.

1) **Formulization of the floor space of commercial buildings model**

The estimation formula of floor space of commercial buildings is shown below. Floor space is estimated by multiplying output of the tertiary industry by the rate of change of the floor space per output, and the floor space per output of the base year. Commercial sector is classified into five. Correspondence with the classification and industry sector is shown in Table 4.8.
\[ FA_{svs} = PD_{svs} \cdot FAG_{svs} \cdot FAGCR_{svs} \]  

(4-11)

Where,

- \( FA_{svs} \): floor space of commercial buildings of commercial sector (m\(^2\))
- \( FAG_{svs} \): floor space per output (base year) (m\(^2\)/RM)
- \( FAGCR_{svs} \): the rate of change of the floor space per output (-)
- \( svs \): commercial sector (\( svs \in pds \))
- \( PD \): Output by industry

### Table 4.8: Correspondence with the classification and industry sector

<table>
<thead>
<tr>
<th>Commercial sector</th>
<th>Industry sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>Transport related, Professional and Business, Other Services, Public administration</td>
</tr>
<tr>
<td>Shop</td>
<td>Wholesale and Retail, Tourism and Hospitality</td>
</tr>
<tr>
<td>Hospital &amp; school</td>
<td>Medical and Education</td>
</tr>
</tbody>
</table>

2) Parameter estimation

Floor space per output was computed by having divided the operating floor area according to commercial sector by value of production. The floor space of commercial buildings per output was computed by having divided the floor space of commercial buildings by commercial sector by output of tertiary industry. The values from the Valuation and Property Services Department, Ministry of Finance, and Malaysia (2007) were used for the value of floor space of commercial buildings. The value of the estimated IO table was used for output of tertiary industry. As a result, the value shown in Table 4.9 was acquired.

### Table 4.9: Floor space per output

<table>
<thead>
<tr>
<th>m(^2)/mil RM</th>
<th>Floor space per output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>43</td>
</tr>
<tr>
<td>Shop</td>
<td>275</td>
</tr>
<tr>
<td>Hospital &amp; school</td>
<td>315</td>
</tr>
</tbody>
</table>
3) Discussion

The estimation formula mentioned above is based on output of industry. However, estimating based on the number of people may be better than estimating based on output of industry in some commercial sectors in order to express the actual condition of floor space of commercial buildings. For example, the number of students (schools), the number of inpatients (hospitals), the number of employees (offices, shops and others). It is necessary using time series data to investigate the validity of formulization as much as possible. However, the estimation formula mentioned above is suitable to estimate floor space because the number of people of commercial sector is related to output of tertiary industry.

4) Other data

The source and the complement method of population related data (population by sex and age cohort, the number of households, labour-force participation ratio) and the number workers by industry besides the above-mentioned data are described in this section.

i) Population by sex and age cohort

Since the data of the population by age group by sex in IM was not obtained, Population by sex and age cohort was computed by multiplying by the population-by-sex percentage of the overall population obtained from CDP and a population-by-age-cohort rate of the States of Johor of Malaysia obtained from Department of Statistics (2006b). As a result, the value shown in Table 4.10 was acquired.

<table>
<thead>
<tr>
<th></th>
<th>0-14</th>
<th>15-64</th>
<th>65+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>208,547</td>
<td>454,017</td>
<td>21,197</td>
</tr>
<tr>
<td>Female</td>
<td>204,179</td>
<td>444,507</td>
<td>20,753</td>
</tr>
</tbody>
</table>

Table 4.10: Population by sex and age cohort
ii) **The number of households**

Since the data of the number of households in the base year was not able to be obtained, the number of households in the base year was computed by multiplying the number of households in 2000 by the rate of change of the number of places of residence from 2000 to 2005. A household is the set which has same household economy. A household may have plural places of residence. The values of Department of Statistics, Malaysia (2001) were used for the number of households and the number of places of residence in 2000. The number of places of residence in 2005 was estimated based on Valuation and Property Services Department, Ministry of Finance, and Malaysia (2006). As a result, the number of households in 2005 shown in Table 4.11 was obtained.

\[
[\text{No. of households (2005)}] = [\text{No. of households (2000)}] \times \frac{[\text{No. of places of residence (2005)}]}{[\text{No. of places of residence (2000)}]} \tag{4-12}
\]

<table>
<thead>
<tr>
<th>Table 4.11: The number of places of residence and households</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Places of residence</td>
</tr>
<tr>
<td>Households</td>
</tr>
</tbody>
</table>

iii) **Labour-force participation ratio**

The labour-force participation ratio in the State of Johor was used for the labour-force participation ratio in IM. The labour-force participation ratio by sex and age cohort is shown in Table 4.12.
iv) No. of workers by industry

Department of Statistics, Malaysia (2006d) was used for the number of workers by industry as the base data of complement estimation. Since the items of the manufacturing industry were unknown, the items of the number of workers engaged in the manufacturing industry of Department of Statistics, Malaysia (2006d) were used as the items of the manufacturing industry. The breakdown of the number of workers by industry in Malaysia was computed from the above two statistics. And the number of workers by industry in Iskandar Malaysia was estimated from the formula (2.49) using the compensation of employees by industry of the Malaysia 2005 IO table and the Iskandar Malaysia 2005 IO table. The estimation result is shown in Table 4.13.

\[ \text{[No. of workers by industry in Iskandar Malaysia]} \]
\[ = \text{[Breakdown of the number of workers by industry in Malaysia]} \]
\[ \times \text{[Compensation of employees by industry in Iskandar Malaysia (RM)]} \]
\[ \div \text{[Compensation of employees by industry in Malaysia (RM)]} \] \hspace{1cm} (4-13)
Table 4.13: The number of workers by industry

<table>
<thead>
<tr>
<th>Industry</th>
<th>Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>24,048</td>
</tr>
<tr>
<td>Mining</td>
<td>0</td>
</tr>
<tr>
<td>Food Products and Beverages</td>
<td>14,284</td>
</tr>
<tr>
<td>Chemicals and Chemical Products</td>
<td>6,416</td>
</tr>
<tr>
<td>Electric and Electronic Products and Machinery</td>
<td>38,690</td>
</tr>
<tr>
<td>Fabricated Metal Products and Machinery</td>
<td>22,858</td>
</tr>
<tr>
<td>Other Non-Metallic</td>
<td>12,081</td>
</tr>
<tr>
<td>Rubber and Plastics Products</td>
<td>23,079</td>
</tr>
<tr>
<td>Construction</td>
<td>67,114</td>
</tr>
<tr>
<td>Transport related</td>
<td>44,998</td>
</tr>
<tr>
<td>Wholesale and Retail</td>
<td>144,146</td>
</tr>
<tr>
<td>Tourism and Hospitality</td>
<td>120,276</td>
</tr>
<tr>
<td>Professional and Business</td>
<td>13,374</td>
</tr>
<tr>
<td>Medical and Education</td>
<td>30,042</td>
</tr>
<tr>
<td>Other Services</td>
<td>16,350</td>
</tr>
<tr>
<td>Public administration</td>
<td>10,279</td>
</tr>
</tbody>
</table>

*Source: Department of Statistics, Malaysia, 2006d, 2006e*

4.5.5 Parameter estimation of energy demand

The parameter about energy demand is estimated from the active mass of an energy balance table and a base year. The parameter about energy demand is estimated from the amount of activities of the base year and the energy balance table.

1) Formulization of the energy demand model

The estimation formula of energy demand is shown below. Energy demanded is estimated by multiplying amount of activities by energy service demand per driving force, fuel share, and the reciprocal of energy efficiency.
\[ ED_{eds,esc,e} = ESDF_{eds,esc} \cdot ESVG_{eds,esc} \cdot ES_{eds,esc} \cdot EE_{eds,esc,e} \]  

(4-14)

where,

\( ED_{eds,esc,e} \): energy demand by energy demand sector, by energy service type, and by fuel type (toe)

\( ESDF_{eds,esc} \): the amount of activities by energy demand sector, by energy service type, and by sector (activity)

\( ESVG_{eds,esc} \): energy service demand per driving force by energy service demand sector and energy service type (toe/activity)

\( ES_{eds,esc} \): fuel share by energy demand sector and energy service type (-)

\( EE_{eds,esc,e} \): the reciprocal of energy efficiency by energy demand sector, by energy service type, and by fuel type (-)

\( eds \): energy demand sector

\( esc \): energy service type

\( e \): fuel type

The amount of activities is a socioeconomic indicator which shows the level of activity of an energy demand sector; residential sector: the number of households, commercial sector: floor space commercial buildings, industry sector: output, transport sector: transport volume. Energy service means the utility acquired by using energy, and it defines as follows.

Energy service demand=Energy demand*Energy efficiency  

(4-15)

In this study, energy efficiency of the base year (2005) is set to 1, and it is considered as follows; the energy demand of the basic year = the energy service demand of the basic year.
2) **Residential and commercial sector**

The energy balance table shows energy demand by fuel type of residential sector and commercial sector, respectively. The energy demand by fuel type per household or per floor space of commercial buildings is obtained by dividing energy demand by the number of households or floor space of commercial buildings. The energy service types of residential sector and commercial sector are cooling, heating, hot water supply, cooking, and others (household appliances and power).

Since the items of the energy service demand by energy service type cannot be grasped, the energy demand by fuel type per household or floor space of commercial buildings is used as the sum total of energy demand by energy service type. The energy demand by fuel type of residential sector and commercial sector is shown in Table 4.14.

<table>
<thead>
<tr>
<th>Unit: ktoe</th>
<th>Coal</th>
<th>Petroleum</th>
<th>Gas</th>
<th>Renewables</th>
<th>Electricity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>0</td>
<td>47</td>
<td>0</td>
<td>0</td>
<td>193</td>
<td>240</td>
</tr>
<tr>
<td>Commercial</td>
<td>0</td>
<td>53</td>
<td>2</td>
<td>0</td>
<td>328</td>
<td>382</td>
</tr>
</tbody>
</table>

3) **Industry sector**

Since it is difficult to grasp the items of energy service type in industry sector, energy service types are not divided in each industry. Energy service demand per driving force (it is the same as the energy demanded per output since energy efficiency of the base year is set to 1) and fuel share are estimated from the energy demand obtained from an energy balance table by fuel type and industry and IO table.
4) Transport sector

The energy service type of passenger transport sector and freight transport sector is a type of mode. Energy service demand is obtained by dividing the energy demand of the energy balance table by the estimated passenger transport volume and freight transport volume in 2005. Fuel share is as follows; Railways (Electricity 100%), and Motor vehicles (Petroleum 99.3%, Gas 0.7%). The parameters about energy demand estimated above are shown in Table 4.15.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Energy service</th>
<th>Basic unit</th>
<th>Fuel share</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Coal</td>
</tr>
<tr>
<td>Residential</td>
<td></td>
<td>0.755 toe/household</td>
<td>0%</td>
</tr>
<tr>
<td>Commercial</td>
<td></td>
<td>55.835 ktoe/m³</td>
<td>0%</td>
</tr>
<tr>
<td>Industry</td>
<td>Agriculture</td>
<td>1.636 ktoe/m³</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Mining</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Food Products and Beverages</td>
<td>56.062 ktoe/m³</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Chemicals and Chemical Products</td>
<td>34.520 ktoe/m³</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Electric and Electronic Products and Machinery</td>
<td>8.394 ktoe/m³</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Fabricated Metal Products and Machinery</td>
<td>5.759 ktoe/m³</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Other Non-Metallic</td>
<td>23.337 ktoe/m³</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>Rubber and Plastics Products</td>
<td>61.498 ktoe/m³</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Construction</td>
<td>10.950 ktoe/m³</td>
<td>0%</td>
</tr>
<tr>
<td>Passenger transport</td>
<td>Passenger railways</td>
<td>0.005 ktoe/ml p-km</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Bus</td>
<td>0.521 ktoe/ml p-km</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Motorcar</td>
<td>0.122 ktoe/ml p-km</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Motorcycle</td>
<td>0.035 ktoe/ml p-km</td>
<td>0%</td>
</tr>
<tr>
<td>Freight transport</td>
<td>Freight railways</td>
<td>0.006 ktoe/ml t-km</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Freight vehicle</td>
<td>0.348 ktoe/ml t-km</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 4.15: Basic units of energy service demand and fuel share (2005)
4.6 Socioeconomic assumption

The socioeconomic assumption in 2025 which is the requisite for the estimation of energy demand and CO₂ emissions was described. CDP was used for description of the qualitative scenario. The value of the exogenous variables and coefficients inputted into ExSS was determined based on the qualitative scenario.

4.6.1 Scenario description

The socioeconomic assumption of Iskandar Malaysia is based on CDP. In Iskandar Malaysia 2005, the following three points are assumed to be important; economic growth, development of communities and society, and environmental protection.

1) Society and values

Fairness is thought as important and it shifts to the social structure which advance in society of women and elderly people was encouraged aiming at the breakaway from the social structure led by male, and was rich in diversity. And safety and amenity are secured for improvement in the quality of life.

2) Energy

The energy consumption in households increases by the diffusion of the energy use appliances for improvement in living standards. However, the increase of energy consumption is controlled by civic efforts to save energy and the technical innovation of appliances.

3) Living

Increase of population progresses with city development. Life style changes and average household size (4.26 per household in 2005) becomes small.
4) **Urban structure and transport**

In order to realize efficient urban structure, land use regulations are performed in business center and residential areas. Public transportation facilities are developed. Regulation about nature conservation is also performed from a viewpoint of environmental protection.

5) **Economy and Industry**

From the industrial structure based on secondary industry, it shifts to the industrial structure with which secondary industry and tertiary industry harmonized. In particular, development of service industries, such as commerce, finance and insurance, sightseeing, is remarkable. In secondary industry, it develops centering on food, chemicals, machinery, etc.

4.6.2 *Setting the cases*

The following two cases were estimated. One is "BaU" (business as usual) about the case where measures against of greenhouse gas emissions reduction are not introduced. Another is "CM" about the case where measures against of greenhouse gas emissions reduction are introduced. "BaU" is the case in consideration of the tendency and the future energy demand trend of technical development accompanying the present economic development, and is the case to which energy service demand per driving force, fuel share, and energy efficiency are changed slightly, respectively. On the other hand, "CM" is the case supposing measure introduction in order to achieve the goal (per capita CO$_2$ emissions from fuel combustion will be reduced 30% by a ratio in 2005.). In addition, the socioeconomic assumption about population, industry, etc. is common to both cases.
4.6.3 Setting input parameters for estimation

The value of each of following items is set up based on the scenario description of the preceding section.

1) **Average number of household members**

From description "Life style changes and average household size becomes small", it is assumed that the average number of household members decreased a little. The average number of household members in 2005 and 2025 is shown in Table 4.16

<table>
<thead>
<tr>
<th>Table 4.16: Average number of household members</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>No. of household members</td>
</tr>
</tbody>
</table>

2) **Demographic composition by sex and age cohort**

The population composition in Malaysia 2025 of World Population Prospects: The 2006 Revision (United Nations, 2007) was used for the population composition of Iskandar Malaysia 2025. The population composition in 2005 is based on the data of five local authorities of Iskandar Malaysia. The population composition by sex and age cohort in 2005 and 2025 is shown in Table 4.17

<table>
<thead>
<tr>
<th>Table 4.17: Demographic composition by sex and age cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age cohort</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>0-14</td>
</tr>
<tr>
<td>15-64</td>
</tr>
<tr>
<td>65+</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>
3) Labour-force participation ratio

The labour-force participation ratio of women and elderly people increases from description of "Fairness is thought as important and it shifts to the social structure which advance in society of women and elderly people was encouraged aiming at the breakaway from the social structure led by male, and was rich in diversity." The labour-force participation ratio in 2005 and 2025 is shown in Table 4.18.

<table>
<thead>
<tr>
<th>Age cohort</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2005</td>
<td>2025</td>
</tr>
<tr>
<td>15-64</td>
<td>82%</td>
<td>90%</td>
</tr>
<tr>
<td>65+</td>
<td>25%</td>
<td>30%</td>
</tr>
</tbody>
</table>

i) Assumption of population

Population is decided by the estimation system of ExSS as follows. Labour demand is first computed from output of industry, and the number of workers required to meet labour demand is computed. Total population is computed by dividing the number of workers with a labour-force participation ratio. By multiplying total population by the population composition by sex and age cohort, the population by sex and age cohort is estimated. This system is adopted because the population of a certain area is decided by the job opportunity of a certain area, in the long run. Since ExSS is a statics tool of a single fiscal year, population dynamics cannot be expressed. Instead, this tool shows "population of the area which maintains balance between assumption of the industry in the target year and population composition when they are given." In order to assume the certain size of population in the target year, the job opportunity (industry) corresponding to it is essential in the area.
4) GDP growth rate

GDP growth rate is assumed 8.0% of the annual average based on CDP.

5) Composition of industry

i) Labour productivity

Labour productivity (output per worker) is assumed that it doubles based on CDP (2005: 57,122RM, 2025: 113,808RM). It deserves the increase in labour productivity of 3.5% of an annual rate.

ii) Exports

The growth rate of exports by industry is set up so that the values of the specific industries which is expected that large growth in CDP are high. The specific industries are Food Products and Beverages, Chemicals and Chemical Products, and Other Non-Metallic in secondary industry. And they are Wholesale and Retail, Tourism and Hospitality, Professional and Business, Medical and Education, and Other Services in tertiary industry. The setting of exports by industry is shown in Table 4.19. Increase of exports by industry is set up the followings; 1.0% of annual average for primary industry, 6.5% of annual average for secondary industry, and 13.2% of annual average for tertiary industry.
Table 4.19: Setting of the values of exports

<table>
<thead>
<tr>
<th>Specific industry</th>
<th>Exports (mil RM)</th>
<th>2025/2005</th>
<th>Annual growth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>443 540</td>
<td>1.22</td>
<td>1.0%</td>
</tr>
<tr>
<td>Mining</td>
<td>0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food Products and Beverages</td>
<td>3,743 28,076</td>
<td>7.50</td>
<td>10.6%</td>
</tr>
<tr>
<td>Chemicals and Chemical Products</td>
<td>4,327 28,066</td>
<td>6.49</td>
<td>9.8%</td>
</tr>
<tr>
<td>Electric and Electronic Products and Machinery</td>
<td>22,503 51,930</td>
<td>2.31</td>
<td>4.3%</td>
</tr>
<tr>
<td>Fabricated Metal Products and Machinery</td>
<td>17,719 38,826</td>
<td>2.19</td>
<td>4.0%</td>
</tr>
<tr>
<td>Other Non-Metallic</td>
<td>3,445 18,611</td>
<td>5.40</td>
<td>8.8%</td>
</tr>
<tr>
<td>Rubber and Plastics Products</td>
<td>4,069 8,915</td>
<td>2.19</td>
<td>4.0%</td>
</tr>
<tr>
<td>Construction</td>
<td>3,168 6,941</td>
<td>2.19</td>
<td>4.0%</td>
</tr>
<tr>
<td>Transport related</td>
<td>4,693 5,714</td>
<td>1.22</td>
<td>1.0%</td>
</tr>
<tr>
<td>Wholesale and Retail</td>
<td>5,303 40,501</td>
<td>7.64</td>
<td>10.7%</td>
</tr>
<tr>
<td>Tourism and Hospitality</td>
<td>6,984 53,340</td>
<td>7.64</td>
<td>10.7%</td>
</tr>
<tr>
<td>Professional and Business</td>
<td>1,716 39,654</td>
<td>23.11</td>
<td>17.0%</td>
</tr>
<tr>
<td>Medical and Education</td>
<td>14 1,250</td>
<td>89.29</td>
<td>25.0%</td>
</tr>
<tr>
<td>Other Services</td>
<td>133 11,519</td>
<td>86.61</td>
<td>25.0%</td>
</tr>
<tr>
<td>Public administration</td>
<td>0 0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

iii) **Input coefficient**

The input coefficient of the target year is the same as that of the base year.

6) **Other final demand**

The setting of the other final demand is shown in Table 4.20. Based on prediction of the State of Johor, private consumption expenditure and government consumption expenditure set to the increase in 10% of an annual average, and gross fixed capital formation set to the increase in more than 10% of an annual average, respectively.

Table 4.20: Final demand of other final demand sector (mil RM)

<table>
<thead>
<tr>
<th>Final demand sector</th>
<th>2005</th>
<th>2025</th>
<th>2025/2005</th>
<th>Annual growth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private consumption expenditure</td>
<td>1,0194</td>
<td>6,8578</td>
<td>6.73</td>
<td>10%</td>
</tr>
<tr>
<td>Government consumption expenditure</td>
<td>2,812</td>
<td>18,916</td>
<td>6.73</td>
<td>10%</td>
</tr>
<tr>
<td>Gross fixed capital formation</td>
<td>4,589</td>
<td>31,034</td>
<td>6.76</td>
<td>10%</td>
</tr>
</tbody>
</table>
7) Details of final demand

The percentage distribution of private consumption expenditure is shown in Table 4.21. The final demand converter is shown in Table 4.22. The percentage distribution of primary industry and secondary industry decreases, and the percentage distribution of tertiary industry increases from assumption that the demand of service industries increases.

Specifically, it is assumed that the consumption of Agriculture, Fabricated Metal Products and Machinery, Other Non-Metallic and Rubber and Plastic Product decreases, and the consumption of Transport related Tourism and Hospitality, Medical and Education and Other Services increases. The percentage distribution of government consumption expenditure and gross fixed capital formation of the target year is the same as that of the base year.

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary industry</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>Secondary industry</td>
<td>45%</td>
<td>42%</td>
</tr>
<tr>
<td>Tertiary industry</td>
<td>47%</td>
<td>54%</td>
</tr>
</tbody>
</table>
Table 4.22: The final demand converter

<table>
<thead>
<tr>
<th>Private consumption</th>
<th>2005</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>0.078</td>
<td>0.040</td>
</tr>
<tr>
<td>Mining</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Food Products and Beverages</td>
<td>0.094</td>
<td>0.094</td>
</tr>
<tr>
<td>Chemicals and Chemical Products</td>
<td>0.018</td>
<td>0.018</td>
</tr>
<tr>
<td>Electric and Electronic Products and Machinery</td>
<td>0.046</td>
<td>0.046</td>
</tr>
<tr>
<td>Fabricated Metal Products and Machinery</td>
<td>0.100</td>
<td>0.085</td>
</tr>
<tr>
<td>Other Non-Metallic</td>
<td>0.107</td>
<td>0.103</td>
</tr>
<tr>
<td>Rubber and Plastics Products</td>
<td>0.080</td>
<td>0.075</td>
</tr>
<tr>
<td>Construction</td>
<td>0.003</td>
<td>0.003</td>
</tr>
<tr>
<td>Transport related</td>
<td>0.052</td>
<td>0.052</td>
</tr>
<tr>
<td>Wholesale and Retail</td>
<td>0.015</td>
<td>0.015</td>
</tr>
<tr>
<td>Tourism and Hospitality</td>
<td>0.102</td>
<td>0.125</td>
</tr>
<tr>
<td>Professional and Business</td>
<td>0.213</td>
<td>0.213</td>
</tr>
<tr>
<td>Medical and Education</td>
<td>0.010</td>
<td>0.031</td>
</tr>
<tr>
<td>Other Services</td>
<td>0.082</td>
<td>0.100</td>
</tr>
<tr>
<td>Public administration</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8) Transport

i) Passenger transport

In the BaU case, it is supposed that passenger transport is the same as that of the base year. Per capita passenger transport demand by sex and age cohort is the same as that of the base year. However, it is supposed that the modal share of railways and buses increases in consideration of public transportation facilities being fixed by development of urban transport system. In the CM case, since the modal shift from passenger cars to public transport is promoted as a low-carbon measure, the modal share of railways and buses increases greatly. Furthermore, since urban structure is advanced to a compact city, it is supposed that the average trip distances of buses, motorcars, and motorcycles are short.

ii) Freight transport

In the BaU case, it is supposed that freight transport is the same as that of the base year. Freight transport demand per output by industry is the same as that of the base year. In the CM case,
since the modal shift from freight vehicles to railways for freight transport is promoted as low-carbon measure, the modal share of railways increases. Furthermore, by improvement in efficiency of logistics, it is supposed that the average trip distance of freight vehicle is short.

9) Primary energy composition of national electricity supply

The primary energy composition of national electricity supply is shown in Table 4.23. The future predicted value of Malaysia in Asia Pacific Energy Research Centre (2006) “APEC Energy Demand and Supply Outlook 2006” is used for the primary energy composition of national electricity supply in 2025.

<table>
<thead>
<tr>
<th></th>
<th>Coal-fired thermal</th>
<th>Oil-fired thermal</th>
<th>Gas-fired thermal</th>
<th>Hydro</th>
<th>Renewables</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>26.5%</td>
<td>2.9%</td>
<td>64.0%</td>
<td>6.6%</td>
<td>0.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2025</td>
<td>47.5%</td>
<td>0.5%</td>
<td>46.5%</td>
<td>5.0%</td>
<td>0.5%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

10) Energy demand

It is supposed that the energy service demand per driving force of residential sector increases by the diffusion of electric appliances for improvement in living standards. The value used in the Shiga Scenario towards realization of sustainable society is used for the energy service demand per driving force of transport sector in the BaU case as a reference value. And energy efficiency increases 10% from that of the base year in the BaU case in consideration of the improvement trend of the technical level of energy use appliances. In the CM case, it is supposed that energy efficiency increases more by introducing low-carbon technology.
11) Other settings

Other settings are shown in Table 4.24. It is supposed that propensity to consumption (private consumption expenditure occupied to the regional gross income) in the target year increases by approximately 1.3 times compared with the base year because of the economic growth. It is supposed that domestic working ratio (percentage of the people works within the region in the workers which live in the region) decreases slightly because workers from Singapore or other States increases.

<table>
<thead>
<tr>
<th>Table 4.24: Other settings</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propensity to consume</td>
<td>-</td>
<td>0.28</td>
</tr>
<tr>
<td>Domestic (within the region) working ratio</td>
<td>-</td>
<td>0.89</td>
</tr>
</tbody>
</table>
4.7 Estimation results

4.7.1 Socioeconomic indicators

The estimation result of main socioeconomic indicators is shown in Table 4.25. The population of Iskandar Malaysia is estimated to be 1.3 million in year 2005 and is estimated to increase 2.2 times to reach 3.0 million in year 2025. The GDP is estimated to increase 4.7 times from 2005 to 2025.

<table>
<thead>
<tr>
<th>Table 4.25: Estimation results of main socioeconomic indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Population</td>
</tr>
<tr>
<td>No. of households</td>
</tr>
<tr>
<td>GDP (mil RM)</td>
</tr>
<tr>
<td>GDP (RM/capita)</td>
</tr>
<tr>
<td>Output (mil RM)</td>
</tr>
<tr>
<td>Primary industry</td>
</tr>
<tr>
<td>Secondary industry</td>
</tr>
<tr>
<td>Tertiary industry</td>
</tr>
<tr>
<td>Floor space of commercial buildings (mil m²)</td>
</tr>
<tr>
<td>Offices</td>
</tr>
<tr>
<td>Shops</td>
</tr>
<tr>
<td>Hospitals &amp; schools</td>
</tr>
</tbody>
</table>
The estimation results of passenger transport volume and freight transport volume are shown in Table 4.26 and Table 4.27.

### Table 4.26: Passenger transport volume (mil p-km)

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2025</th>
<th>Transport volume share</th>
<th>BaU Transport volume</th>
<th>CM Transport volume</th>
<th>Transport volume change ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railways</td>
<td>23</td>
<td>222</td>
<td>0.01</td>
<td>0.03</td>
<td>395</td>
<td>9.65 17.17 1.78</td>
</tr>
<tr>
<td>Bus</td>
<td>65</td>
<td>987</td>
<td>0.02</td>
<td>0.11</td>
<td>1,350</td>
<td>15.18 20.77 1.37</td>
</tr>
<tr>
<td>Motorcar</td>
<td>2,374</td>
<td>5,431</td>
<td>0.62</td>
<td>0.63</td>
<td>2,731</td>
<td>2.29 1.15 0.50</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>1,005</td>
<td>1,481</td>
<td>0.26</td>
<td>0.17</td>
<td>978</td>
<td>1.47 0.97 0.66</td>
</tr>
<tr>
<td>Walk</td>
<td>163</td>
<td>247</td>
<td>0.04</td>
<td>0.03</td>
<td>219</td>
<td>1.52 1.34 0.89</td>
</tr>
<tr>
<td>Bicycle</td>
<td>186</td>
<td>309</td>
<td>0.05</td>
<td>0.04</td>
<td>329</td>
<td>1.66 1.77 1.06</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3,816</td>
<td>8,677</td>
<td>1.00</td>
<td>1.00</td>
<td>6,003</td>
<td>2.27 1.57 0.69</td>
</tr>
</tbody>
</table>

### Table 4.27: Freight transport volume (mil t-km)

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2025</th>
<th>Transport volume share</th>
<th>BaU Transport volume</th>
<th>CM Transport volume</th>
<th>Transport volume change ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railways</td>
<td>11</td>
<td>33</td>
<td>0.01</td>
<td>0.01</td>
<td>1,073</td>
<td>3.15 102.14 32.43</td>
</tr>
<tr>
<td>Freight vehicle</td>
<td>1,642</td>
<td>5,171</td>
<td>0.99</td>
<td>0.99</td>
<td>3,734</td>
<td>3.15 2.27 0.72</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,652</td>
<td>5,204</td>
<td>1.00</td>
<td>1.00</td>
<td>4,807</td>
<td>3.15 2.91 0.92</td>
</tr>
</tbody>
</table>

The output by industry is shown in Table 4.28.
Table 4.28: Output by industry

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary industry</td>
<td>1,860</td>
<td>5,375</td>
<td>2.89</td>
<td>0.02</td>
<td>0.01</td>
<td>0.74</td>
</tr>
<tr>
<td>Agriculture</td>
<td>1,860</td>
<td>5,375</td>
<td>2.89</td>
<td>0.02</td>
<td>0.01</td>
<td>0.74</td>
</tr>
<tr>
<td>Mining</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Secondary industry</td>
<td>83,502</td>
<td>263,444</td>
<td>3.15</td>
<td>0.69</td>
<td>0.56</td>
<td>0.81</td>
</tr>
<tr>
<td>Food Products and Beverages</td>
<td>9,228</td>
<td>58,715</td>
<td>6.36</td>
<td>0.08</td>
<td>0.12</td>
<td>1.63</td>
</tr>
<tr>
<td>Chemicals and Chemical Products</td>
<td>6,651</td>
<td>37,422</td>
<td>5.63</td>
<td>0.05</td>
<td>0.08</td>
<td>1.44</td>
</tr>
<tr>
<td>Electric and Electronic Products and Machinery</td>
<td>26,803</td>
<td>61,826</td>
<td>2.31</td>
<td>0.22</td>
<td>0.13</td>
<td>0.59</td>
</tr>
<tr>
<td>Fabricated Metal Products and Machinery</td>
<td>22,032</td>
<td>48,531</td>
<td>2.20</td>
<td>0.18</td>
<td>0.10</td>
<td>0.56</td>
</tr>
<tr>
<td>Other Non-Metallic</td>
<td>5,378</td>
<td>24,664</td>
<td>4.59</td>
<td>0.04</td>
<td>0.05</td>
<td>1.17</td>
</tr>
<tr>
<td>Rubber and Plastics Products</td>
<td>7,095</td>
<td>18,908</td>
<td>2.66</td>
<td>0.06</td>
<td>0.04</td>
<td>0.68</td>
</tr>
<tr>
<td>Construction</td>
<td>6,315</td>
<td>13,378</td>
<td>2.12</td>
<td>0.05</td>
<td>0.03</td>
<td>0.54</td>
</tr>
<tr>
<td>Tertiary industry</td>
<td>36,069</td>
<td>205,309</td>
<td>5.69</td>
<td>0.30</td>
<td>0.43</td>
<td>1.46</td>
</tr>
<tr>
<td>Transport related</td>
<td>7,226</td>
<td>11,996</td>
<td>1.66</td>
<td>0.06</td>
<td>0.03</td>
<td>0.43</td>
</tr>
<tr>
<td>Wholesale and Retail</td>
<td>11,358</td>
<td>58,694</td>
<td>5.17</td>
<td>0.09</td>
<td>0.12</td>
<td>1.32</td>
</tr>
<tr>
<td>Tourism and Hospitality</td>
<td>9,261</td>
<td>59,486</td>
<td>6.42</td>
<td>0.08</td>
<td>0.13</td>
<td>1.65</td>
</tr>
<tr>
<td>Professional and Business</td>
<td>3,887</td>
<td>48,547</td>
<td>12.49</td>
<td>0.03</td>
<td>0.10</td>
<td>3.20</td>
</tr>
<tr>
<td>Medical and Education</td>
<td>1,840</td>
<td>7,783</td>
<td>4.23</td>
<td>0.02</td>
<td>0.02</td>
<td>1.08</td>
</tr>
<tr>
<td>Other Services</td>
<td>1,705</td>
<td>17,996</td>
<td>10.56</td>
<td>0.01</td>
<td>0.04</td>
<td>2.70</td>
</tr>
<tr>
<td>Public administration</td>
<td>793</td>
<td>807</td>
<td>1.02</td>
<td>0.01</td>
<td>0.00</td>
<td>0.26</td>
</tr>
<tr>
<td><strong>Total (mil RM)</strong></td>
<td>121,431</td>
<td>474,129</td>
<td>3.90</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

4.7.2 Energy demand and CO₂ emissions

1) Energy demand

The estimation results of final energy demand is shown in Table 4.29 and primary energy demand is shown in Table 4.30. The final energy demand in the BaU case is 10,936 ktoe. It is 5,915 ktoe in the CM case, and it is 1.80 times of that in 2005, and 0.54 times of that in the BaU case. In the primary energy demand, the composition ratio of petroleum decreases sharply from 53% (2005) to 12% (2025). The composition ratio of natural gas increases sharply from 37% (2005) to 63% (2025). This is because fuel share of motor vehicles shifts from gasoline to natural gas. The composition ratio of renewable energy (photovoltaic, wind power, and biomass) is 8% (2025).
Table 4.29: Estimation results of final energy demand

### 2005

<table>
<thead>
<tr>
<th></th>
<th>Coal</th>
<th>Petroleum</th>
<th>Gas</th>
<th>Renewable</th>
<th>Electricity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>0</td>
<td>47</td>
<td>0</td>
<td>0</td>
<td>193</td>
<td>240</td>
</tr>
<tr>
<td>Commercial</td>
<td>0</td>
<td>53</td>
<td>2</td>
<td>0</td>
<td>328</td>
<td>382</td>
</tr>
<tr>
<td>Industry</td>
<td>50</td>
<td>679</td>
<td>623</td>
<td>0</td>
<td>381</td>
<td>1,733</td>
</tr>
<tr>
<td>Passenger transport</td>
<td>0</td>
<td>357</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>359</td>
</tr>
<tr>
<td>Freight transport</td>
<td>0</td>
<td>568</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>572</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>50</td>
<td>1,704</td>
<td>632</td>
<td>0</td>
<td>901</td>
<td>3,286</td>
</tr>
</tbody>
</table>

### 2025BaU

<table>
<thead>
<tr>
<th></th>
<th>Coal</th>
<th>Petroleum</th>
<th>Gas</th>
<th>Renewable</th>
<th>Electricity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>0</td>
<td>213</td>
<td>1</td>
<td>0</td>
<td>877</td>
<td>1,091</td>
</tr>
<tr>
<td>Commercial</td>
<td>0</td>
<td>135</td>
<td>4</td>
<td>0</td>
<td>839</td>
<td>978</td>
</tr>
<tr>
<td>Industry</td>
<td>228</td>
<td>2,594</td>
<td>2,367</td>
<td>0</td>
<td>1,446</td>
<td>6,635</td>
</tr>
<tr>
<td>Passenger transport</td>
<td>0</td>
<td>585</td>
<td>4</td>
<td>200</td>
<td>1</td>
<td>790</td>
</tr>
<tr>
<td>Freight transport</td>
<td>0</td>
<td>1,432</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>1,442</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>228</td>
<td>4,960</td>
<td>2,386</td>
<td>200</td>
<td>3,163</td>
<td>10,936</td>
</tr>
</tbody>
</table>

### 2025CM

<table>
<thead>
<tr>
<th></th>
<th>Coal</th>
<th>Petroleum</th>
<th>Gas</th>
<th>Renewable</th>
<th>Electricity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>0</td>
<td>16</td>
<td>52</td>
<td>130</td>
<td>452</td>
<td>649</td>
</tr>
<tr>
<td>Commercial</td>
<td>0</td>
<td>18</td>
<td>25</td>
<td>49</td>
<td>592</td>
<td>685</td>
</tr>
<tr>
<td>Industry</td>
<td>100</td>
<td>346</td>
<td>2,275</td>
<td>0</td>
<td>774</td>
<td>3,494</td>
</tr>
<tr>
<td>Passenger transport</td>
<td>0</td>
<td>70</td>
<td>116</td>
<td>65</td>
<td>2</td>
<td>253</td>
</tr>
<tr>
<td>Freight transport</td>
<td>0</td>
<td>230</td>
<td>384</td>
<td>213</td>
<td>6</td>
<td>834</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>680</td>
<td>2,852</td>
<td>457</td>
<td>1,825</td>
<td>5,915</td>
</tr>
</tbody>
</table>
Table 4.30: Primary energy demand (ktoe)

<table>
<thead>
<tr>
<th>Energy demand</th>
<th>Coal</th>
<th>Petroleum</th>
<th>Gas</th>
<th>Hydro</th>
<th>Renewables</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>289</td>
<td>1,729</td>
<td>1,209</td>
<td>60</td>
<td>0</td>
<td>3,286</td>
</tr>
<tr>
<td>2025BaU</td>
<td>1,844</td>
<td>4,978</td>
<td>3,854</td>
<td>61</td>
<td>7</td>
<td>10,743</td>
</tr>
<tr>
<td>2025CM</td>
<td>1,032</td>
<td>691</td>
<td>3,699</td>
<td>35</td>
<td>457</td>
<td>5,915</td>
</tr>
</tbody>
</table>

Percentage distribution

<table>
<thead>
<tr>
<th></th>
<th>Coal</th>
<th>Petroleum</th>
<th>Gas</th>
<th>Hydro</th>
<th>Renewables</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>9%</td>
<td>53%</td>
<td>37%</td>
<td>2%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>2025BaU</td>
<td>17%</td>
<td>46%</td>
<td>36%</td>
<td>1%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>2025CM</td>
<td>17%</td>
<td>12%</td>
<td>63%</td>
<td>1%</td>
<td>8%</td>
<td>100%</td>
</tr>
</tbody>
</table>

2) CO₂ emissions

The estimation result of CO₂ emissions is shown in Table 4.31. CO₂ emissions increase 3.62 times of that in 2005 in the BaU case, and 1.56 times of that in 2005 in the CM case. In the CM case, it is 0.43 times of that in the BaU case. Per capita CO₂ emissions increase from 9.3 t-CO₂ (2005) to 15.1 t-CO₂ in the BaU case (2025), and 6.5 t-CO₂ in the CM case in 2025. Therefore, Per capita CO₂ emissions in the CM case are reduced 30% by the ratio in 2005. The reduction rate of passenger transport sector is the largest according to sector.

Table 4.31: CO₂ emissions (kt-CO₂)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>1,468</td>
<td>7,715</td>
<td>2,972</td>
<td>5.26</td>
<td>2.02</td>
<td>0.39</td>
</tr>
<tr>
<td>Commercial</td>
<td>2,419</td>
<td>7,195</td>
<td>3,802</td>
<td>2.97</td>
<td>1.57</td>
<td>0.53</td>
</tr>
<tr>
<td>Industry</td>
<td>6,035</td>
<td>24,832</td>
<td>10,897</td>
<td>4.11</td>
<td>1.81</td>
<td>0.44</td>
</tr>
<tr>
<td>Passenger transport</td>
<td>1,015</td>
<td>1,672</td>
<td>447</td>
<td>1.65</td>
<td>0.44</td>
<td>0.27</td>
</tr>
<tr>
<td>Freight transport</td>
<td>1,615</td>
<td>4,070</td>
<td>1,481</td>
<td>2.52</td>
<td>0.92</td>
<td>0.36</td>
</tr>
<tr>
<td>Total</td>
<td>12,552</td>
<td>45,484</td>
<td>19,598</td>
<td>3.62</td>
<td>1.56</td>
<td>0.43</td>
</tr>
</tbody>
</table>
3) Low-carbon measures

The reduction potential by measure type is shown in Figure 4.6: Reduction potential by measure type. The list of introduced low-carbon measures is shown in Table 4.32: List of low-carbon measures. The reduction potential is the amount of CO$_2$ emissions reduction potential against the BaU case. The reduction potential of energy efficiency improvement (introduction of high energy efficiency machinery and appliances) in industry sector is about 43% of the whole reduction potential, and it is the largest reduction potential. The reduction potential of fuel shift (converting into low-carbon fuel) is about 15% of the whole reduction potential.

![Figure 4.6: Reduction potential by measure type](image-url)


### Table 4.32: List of low-carbon measures

<table>
<thead>
<tr>
<th>Sector</th>
<th>Low-carbon measures &amp; technologies</th>
<th>Specification</th>
<th>Source</th>
<th>Measure Setting/service type (use: fuel type)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioner (highest efficiency)</td>
<td>COP</td>
<td>6.60 *2</td>
<td>Diffusion rate (cooling)</td>
<td>100%</td>
</tr>
<tr>
<td>Oil water heater (high efficiency)</td>
<td>COP</td>
<td>0.83 *1</td>
<td>Diffusion rate (hot water: petroleum)</td>
<td>80%</td>
</tr>
<tr>
<td>Gas heater (latent heat recovery)</td>
<td>COP</td>
<td>0.83 *1</td>
<td>Diffusion rate (hot water: gas)</td>
<td>100%</td>
</tr>
<tr>
<td>Heat pump water heater</td>
<td>COP</td>
<td>4.50</td>
<td>Diffusion rate (hot water: electricity)</td>
<td>80%</td>
</tr>
<tr>
<td>Gas stove (high efficiency)</td>
<td>Thermal efficiency (base year = 1)</td>
<td>1.22 *1</td>
<td>Diffusion rate (kitchen: gas)</td>
<td>100%</td>
</tr>
<tr>
<td>Electric stove (high efficient)</td>
<td>Electrical consumption (base year = 1)</td>
<td>1.15 *1</td>
<td>Diffusion rate (kitchen: electricity)</td>
<td>80%</td>
</tr>
<tr>
<td>Efficiency improvement of other electric appliances</td>
<td>Electrical consumption (base year = 1)</td>
<td>0.48 *1</td>
<td>Diffusion rate (kitchen: electricity)</td>
<td>80%</td>
</tr>
<tr>
<td>Fluorescent light (incandescent type)</td>
<td>Electrical consumption (base year = 1)</td>
<td>4.35 *1</td>
<td>Diffusion rate (incandescent)</td>
<td>20%</td>
</tr>
<tr>
<td>LED (incandescent light alternative)</td>
<td>Electrical consumption (base year = 1)</td>
<td>8.70 *1</td>
<td>Diffusion rate (incandescent)</td>
<td>80%</td>
</tr>
<tr>
<td>Commercial</td>
<td>Efficiency improvement of other electric devices</td>
<td>Electrical consumption (base year = 1)</td>
<td>1.33 *1</td>
<td>Diffusion rate (fluorescent)</td>
</tr>
<tr>
<td>Gas kitchen (high efficiency)</td>
<td>Efficiency consumption (base year = 1)</td>
<td>2.67 *1</td>
<td>Diffusion rate (fluorescent)</td>
<td>25%</td>
</tr>
<tr>
<td>Insulation level improvement of house (next generation standard)</td>
<td>Thermal loss (base year = 1)</td>
<td>0.42 *3</td>
<td>Diffusion rate</td>
<td>80%</td>
</tr>
<tr>
<td>Behaviour changes for energy saving</td>
<td>*6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar water heater</td>
<td>Introduction amount (ktoe)</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>Air conditioner (dedicated, high efficient)</td>
<td>COP</td>
<td>2.85 *1</td>
<td>Diffusion rate (cooling: electricity)</td>
</tr>
<tr>
<td>Gas kitchen (high efficiency)</td>
<td>Efficiency consumption (base year = 1)</td>
<td>1.15</td>
<td>Diffusion rate (kitchen: gas)</td>
<td>80%</td>
</tr>
<tr>
<td>Efficiency improvement of other electric devices</td>
<td>Efficiency consumption (base year = 1)</td>
<td>0.41</td>
<td>Diffusion rate (kitchen: electricity)</td>
<td>40%</td>
</tr>
<tr>
<td>LED (incandescent light alternative)</td>
<td>Efficiency consumption (base year = 1)</td>
<td>4.55 *1</td>
<td>Diffusion rate (incandescent)</td>
<td>50%</td>
</tr>
<tr>
<td>Gas heater (high efficient)</td>
<td>Efficiency consumption (base year = 1)</td>
<td>3.95 *1</td>
<td>Diffusion rate (gas: fluorescent)</td>
<td>25%</td>
</tr>
<tr>
<td>High insulation commercial building</td>
<td>Thermal loss (base year = 1)</td>
<td>0.60 *1</td>
<td>Diffusion rate</td>
<td>100%</td>
</tr>
<tr>
<td>BEMS</td>
<td>Reduction rate of energy service demand</td>
<td>10%</td>
<td>Diffusion rate</td>
<td>50%</td>
</tr>
<tr>
<td>Behaviour changes for energy saving</td>
<td>*6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar water heater</td>
<td>Introduction amount (ktoe)</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid passenger vehicle</td>
<td>Fuel efficiency (conventional)</td>
<td>0.6</td>
<td>Diffusion rate</td>
<td>50%</td>
</tr>
<tr>
<td>Modal shift</td>
<td>from motorcar &amp; motorcycle to others</td>
<td>Conversion ratio</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>to walk and bicycle</td>
<td>Conversion ratio</td>
<td>5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>to railway</td>
<td>Conversion ratio</td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>to bus</td>
<td>Conversion ratio</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bo-fuel</td>
<td>from petroleum to bio-fuel</td>
<td>Diffusion rate</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>Freight transport</td>
<td>Modal shift</td>
<td>from freight vehicle to freight train</td>
<td>Conversion ratio</td>
<td>10%</td>
</tr>
<tr>
<td>to walk and bicycle</td>
<td>Conversion ratio</td>
<td>3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>to railway</td>
<td>Conversion ratio</td>
<td>5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>to bus</td>
<td>Conversion ratio</td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bo-fuel</td>
<td>from petroleum to bio-fuel</td>
<td>Diffusion rate</td>
<td>20%</td>
<td></td>
</tr>
</tbody>
</table>

* 1 みずほ信託総合研究所(2005): シナリオ作成のための調査及びシミュレーション作業調査報告書:「第4国対策シナリオ」
* 2 太陽エネルギー総合研究所(2007): 太陽エネルギー実施技術研究のための調査調査報告書:「第2国対策シナリオ」
* 3 環境省(2001):平成12年度温室効果ガス削減技術シナリオ策定調査検討会報告書より、
* 4 大阪ガスHP: http://www.okasakagas.co.jp/Pages/pj03030213.htm
* 5 経済産業省(2005):「技術政策」デジタルエネルギー・光電気エネルギー技術シンポジウム
* 6 産業技術総合研究所(2005):「技術政策」デジタルエネルギー技術シンポジウム
* 7 煤エネルギー産業技術総合研究所(2005):「技術政策」デジタルエネルギー技術シンポジウム
* 8 煤エネルギー産業技術総合研究所(2005):「技術政策」デジタルエネルギー技術シンポジウム
* 9 日本経済新聞朝刊(2008年3月14日)
The Structure of Focus Group Discussions in Iskandar Malaysia

There are three main session in this Focus Group Discussion (FGD I) categories; 1) preparations before the FGD, 2) events during FGD and 3) output/results after the FGD session. The Preparations before the FGD event is a very important session. This is when the team members organize as to how the whole event will take place and if it will be a success or not. The first thing to do is to identify the objective of having this FGD. For Iskandar Regional Development Authority (IRDA), we conducted this study to:

i. Identify the availability of data; in IRDA and the other Government agencies in Iskandar Malaysia (IM)

ii. To learn and understand the current and future plans IRDA has for the development in IM.

Once the objective is set, the project team which consists of both the Local Authority; who are IM, and the team of Researchers meet together and identify the persons who will be moderating the FGD session. A Moderator is needed to make sure the Objective is met and the FGD does not go beyond time limitations, and out of topic.

Since FGD was an in-house event, we had it at the office building in IRDA and was attended by about 15 members from the IRDA. They were from all the various departments in IRDA. The refreshment (food and drinks) for the session was provided by IRDA. It is important to have these refreshments because, when a group of people meet together with food and drinks, there is always a better sense of getting to know one another. Hence this is a good chance for everyone to learn more about each other’s background and how their expertise can contribute towards this project.
At the end of the FGD I session, all data for the IRDA study area were compiled together by the Project team. From there forth a brochure about Low Carbon City 2025 Sustainable Iskandar Malaysia was published. The steps taken in FGD I can be seen in Figure 4.7.

**Figure 4.7: Structure of FGD, Phase I in IRDA**

However, in the case study of IRDA, the Focus Group Discussion II (FGD II) session is not held. This is still in the process of being carried out. Figure 4.8 is a proposal as to how FGD II might be held in IRDA. This will be part of the future research that should be carried out in Iskandar Malaysia towards the effort of implementing a successful Low Carbon Society within Iskandar Malaysia.
4.9 Conclusion of Low Carbon Society research in Iskandar Malaysia

During the time period of this research in Iskandar Malaysia study area, the two targets which were set at the beginning of the research were able to be achieved. The targets are as follows:

i. 30% reduction of per capita CO₂ emission from 2025BaU to 2025CM (with counter measure)

ii. 50% reduction of CO₂ emission intensity from 2005 to 2025CM

The CO₂ emission per capita was reduced from 9.89 t-CO₂/person (2025BaU) to 6.80 t-CO₂/person (2025CM). This accounts to about 30% reduction. As for the CO₂ emission intensity (CO₂/GDP), from 2005 the level of 0.93kt-CO₂/USD is reduced by 50% to achieve 0.46kt-CO₂/USD in 2025CM.

---

**Figure 4.8: Structure of FGD, Phase II in IRDA**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prepare the Materials for this Session</td>
</tr>
<tr>
<td>2</td>
<td>Have Internal Discussion</td>
</tr>
<tr>
<td>3</td>
<td>Identify Function of task force</td>
</tr>
<tr>
<td>4</td>
<td>Identify &amp; Invite participants</td>
</tr>
<tr>
<td>5</td>
<td>Set the venue for FGD</td>
</tr>
<tr>
<td>6</td>
<td>Costing for FGD Session</td>
</tr>
<tr>
<td>7</td>
<td>Register Participants</td>
</tr>
<tr>
<td>8</td>
<td>Presentation by main speakers &amp; forum</td>
</tr>
<tr>
<td>9</td>
<td>Break into Groups for Discussion</td>
</tr>
<tr>
<td>10</td>
<td>Final Group presentation</td>
</tr>
<tr>
<td>11</td>
<td>Prepare Final Report of Policy Guideline</td>
</tr>
</tbody>
</table>

---

Preparations Before the FGD II Sessions

<table>
<thead>
<tr>
<th>Task</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Task force</td>
<td>to discuss these results with the Team of Researchers involved in this Study</td>
</tr>
<tr>
<td>Moderators &amp; chairman</td>
<td>who will facilitate the Session.</td>
</tr>
<tr>
<td>Presenters who will present at FGD II</td>
<td></td>
</tr>
<tr>
<td>Persons to take minutes at the FGD II</td>
<td></td>
</tr>
<tr>
<td>Identify the number of persons who will attend this session.</td>
<td></td>
</tr>
<tr>
<td>May be a bigger crowd (50 persons - 100 Persons)</td>
<td></td>
</tr>
<tr>
<td>Venue suitable for Presentations and Forum like discussions.</td>
<td></td>
</tr>
<tr>
<td>Poster exhibitions</td>
<td></td>
</tr>
</tbody>
</table>

During the FGD II Sessions

<table>
<thead>
<tr>
<th>Task</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Divide participants into groups (5-10 persons), determined by the types of Actions which are being introduced in IM.</td>
<td></td>
</tr>
<tr>
<td>According to agencies/ departments</td>
<td></td>
</tr>
<tr>
<td>Allocate about 2 hours for this</td>
<td></td>
</tr>
<tr>
<td>Each group to discuss the Research output from FGD I &amp; the comment on the List of Policy Actions being Proposed for IM.</td>
<td></td>
</tr>
<tr>
<td>1 hour for this session.</td>
<td></td>
</tr>
<tr>
<td>Each Group representative to Present the results.</td>
<td></td>
</tr>
</tbody>
</table>

After FGD II Session

<table>
<thead>
<tr>
<th>Task</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Task Force</td>
<td>– gather all the feedback from this FGD II</td>
</tr>
<tr>
<td>Write the Final Report with the Proposed Actions &amp; Guidelines for LCS1M 2025</td>
<td></td>
</tr>
</tbody>
</table>
In the implementation methodology section this results were discussed with the policy makers in Iskandar Malaysia, and the results were presented in the brochure as seen in Figure 4.9. The Focus Group Discussion sessions were not held during the time frame of this research, however the LCS activities in IM are currently on-going and the FGD sessions are to be held in 2012.

![Figure 4.9: Low Carbon City 2025, Sustainable Iskandar Malaysia Brochure](image-url)
5  THE CASE STUDY OF PUTRAJAYA

5.1  Introduction to Putrajaya

The creation of a new Federal Government Administrative Centre at Putrajaya marks a new chapter in the development history of modern Malaysia. The development of this city was prompted by the government’s desire and the dire need to balance and disperse development to areas outside of the capital city of Malaysia, Kuala Lumpur, hence improving the urban environment and quality of life, as well as easing the pressure on the overstretched infrastructure of Kuala Lumpur.

Putrajaya is a plan driven city based on two underlying concepts, the city in the garden and the intelligent city. The adoption of these concepts to guide its physical development was aimed at a balanced and sustainable development, environmentally, socially, as well as economically. Sustainability concept is clearly evident in the designation of almost 40% of its total city area of 4,931 hectares specifically for green and open spaces in the Putrajaya Master Plan Table 5.1

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Hectares</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>225</td>
<td>4.6%</td>
</tr>
<tr>
<td>Residential</td>
<td>711</td>
<td>14.4%</td>
</tr>
<tr>
<td>Commercial</td>
<td>139</td>
<td>2.8%</td>
</tr>
<tr>
<td>Mixed Use</td>
<td>41</td>
<td>0.8%</td>
</tr>
<tr>
<td>Special Use</td>
<td>139</td>
<td>2.8%</td>
</tr>
<tr>
<td>Service Industry</td>
<td>11</td>
<td>0.2%</td>
</tr>
<tr>
<td>Public Amenity</td>
<td>344</td>
<td>7.0%</td>
</tr>
<tr>
<td>Open Space</td>
<td>1930</td>
<td>39.2%</td>
</tr>
<tr>
<td>Infrastructure &amp; Utility</td>
<td>483</td>
<td>9.8%</td>
</tr>
<tr>
<td>Road</td>
<td>908</td>
<td>18.4%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4,931</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

*Source: Laporan Pemeriksaan Draf Rancangan Struktur Putrajaya, June 2009 (Perbandaran Putrajaya, 2009)*
In brief, the distinguishing features of the Master Plan are as follows:

- Planned population is about 347,000 people.
- A large proportion of the city area is designated as green open space;
- A large water body (600 hectares) of man-made lakes and wetlands was formed by utilizing the small rivers which run through the area;
- The lake created a 38 kilometres long waterfront area;
- Open spaces are developed according to a complete hierarchy, including 12 metropolitan parks; and a 4.2 km long boulevard forms the central spine of the city.

5.2 **Background of Putrajaya Green City 2025 Study**

The research conducted in Putrajaya involves the Local Authority in Putrajaya which is known as Putrajaya Corporation (PJC). The name of this research was determined by the Project team and it is identified as Putrajaya Green City Study 2025 (PGC 2025). This project which commenced in May 2010 and ended in August 2011 was carried out by a team of researchers, and local authority members and members from the government.

The Putrajaya Green City 2025 study began as a research document to support the interest of the Malaysian Government. The Prime Minister of Malaysia; Y.A.B. Dato’ Sri Mohd Najib bin Tun Abdul Razak in his speech during the 2010 Budget, on the 23rd October 2009, mentioned his interest to “…develop Putrajaya and Cyberjaya as pioneer township in Green Technology as a show case for the development of other townships”.

103
Table 5.2: List of Research Team Members

<table>
<thead>
<tr>
<th>Name (Research Members)</th>
<th>Affiliation</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Prof. Ho Chin Siong</td>
<td>Universiti Teknologi Malaysia</td>
<td>Professor, Leader of the team</td>
</tr>
<tr>
<td>2 Mr. Azman Zainal Abidin</td>
<td>Malaysia Green Technology Corporation</td>
<td>Deputy Director Policy Analysis &amp; Research Management</td>
</tr>
<tr>
<td>3 Mr. Omairi bin Hashim</td>
<td>Putrajaya Corporation (PJC)</td>
<td>Director of Town Planning</td>
</tr>
<tr>
<td>4 Mr. Azizi Ahmad Termizi</td>
<td>Putrajaya Corporation (PJC)</td>
<td>Deputy Director of Town Planning</td>
</tr>
<tr>
<td>5 Prof. Yuzuru MATSUOKA</td>
<td>Kyoto University</td>
<td>Professor, Graduate School of Engineering</td>
</tr>
<tr>
<td>6 Prof. Takeshi FUJIWARA</td>
<td>Okayama University</td>
<td>Professor, Graduate School of Environmental Science</td>
</tr>
<tr>
<td>7 Prof. Gakuji KURATA</td>
<td>Kyoto University</td>
<td>Associate Professor, Graduate School of Engineering</td>
</tr>
<tr>
<td>8 Dr. Junichi FUJINO</td>
<td>National Institute for Environmental Studies, Japan</td>
<td>Senior Researcher</td>
</tr>
</tbody>
</table>

In response to his speech, the research team of Kyoto University and Universiti Teknologi Malaysia (UTM) joined forces to draw a research framework to cater to the need of creating Putrajaya as a Green City. As the first step towards starting the project a project team was aligned. The methodology of running this project will be discussed in the next section. In line with this research plan, Kyoto University and UTM set up a research team which comprises with the below mentioned to come out with a research plan for the Putrajaya Green City 2025 Study.
Table 5.3: List of Task Force Members

<table>
<thead>
<tr>
<th>Name (Task Force)</th>
<th>Affiliation</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Kei GOMI</td>
<td>Kyoto University</td>
<td>Research Fellow, Graduate School of Engineering (GSE)</td>
</tr>
<tr>
<td>Mr. Azhar bin Othman</td>
<td>Putrajaya Corporation (PJC)</td>
<td>Senior Assistant Director of Planning Department</td>
</tr>
<tr>
<td>Ms. Wang Tze Wee</td>
<td>Putrajaya Corporation (PJC)</td>
<td>Assistant Director of Planning Department</td>
</tr>
<tr>
<td>Ms. Maiko SUDA</td>
<td>NIES</td>
<td>Assistant Fellow</td>
</tr>
<tr>
<td>Dr. Genku KAYO</td>
<td>NIES</td>
<td>Post-doctoral fellow</td>
</tr>
<tr>
<td>Ms. Janice Jeevamalar Simson</td>
<td>Kyoto University</td>
<td>Ph. D candidate, (GCE)</td>
</tr>
<tr>
<td>Ms. Siti Norbaizura</td>
<td>Okayama University</td>
<td>Graduate Student, Graduate School of Environmental Science</td>
</tr>
<tr>
<td>Ms. Yuri HAYASHI</td>
<td>Kyoto University</td>
<td>Undergraduate Student, (GCE)</td>
</tr>
<tr>
<td>Mr. Tomohito HAMADA</td>
<td>Okayama University</td>
<td>Undergraduate Student, Graduate School of Environmental Science</td>
</tr>
</tbody>
</table>

5.3 Methodology of Implementing Low Carbon Society in Putrajaya

The flow chart in Figures 5.1 presents the detailed structure of implementing Low Carbon Society (LCS) actions and development in Putrajaya. This flow chart is customized for the case of Putrajaya. This is an adaptation of the Methodology introduced in Chapter 3 (Figure 3.1)

The research conducted in Putrajaya successfully completed in accordance to this methodology. The quantification methodology section was conducted based on the data collected from Putrajaya Corporation (PJC). PJC is the Local Authority in Putrajaya. The quantification tool used here is the Community Extended Snapshot tool (C-ExSS) and the calculation methods will be discussed in this chapter.

As for the implementation methodology section of this research, it was conducted based on the methodology of Focus Group Discussions (FGD).
1. Form an alliance with PJC

2. Form a project team
   ➢ Consisting of PJC members and other researchers

3. Design the framework of research
   ➢ Low Carbon Region. Putrajaya Green City 2025 (PGC 2025)
   ➢ 6-12 months target completion

4. Projection of Socio-economic scenarios
   ➢ Estimation of energy demand & CO2 emission levels

5. Designate duty/role of project team

5a. Researcher:
   ➢ Advisor to task force
   ➢ Prepare and facilitate Focus Group Discussion (FGD I & II)
   ➢ Have intensive discussion with Task force in preparing materials for FGDs

5b. Task Force members:
   ➢ Data Collection (PJC assists)
   ➢ Estimate socio-economic scenario for Putrajaya
   ➢ Use C-ExSS tool to identify CO2 emission & energy demand in Putrajaya
   ➢ Set Counter Measures and propose List of Actions

6. Focus Group Discussion I (FGD I)

7. Revise Step 4 with feedback from Step 6

8. Focus Group Discussion II (FGD II)

9. Revise results based on FGD II

10. Present output from FGDs and C-ExSS to PJC

11. Present Output Based on Comments.
   ➢ Present the final output to PJC


13. PJC Introduces PGC 2025 Targets & Implement the Dozen Actions and introduce LCS Policies

14. Determine the Success
   ➢ This can only be determined when these LCS policies are implemented for a period of time based on Target Year set.
   ➢ Possibly an emission reduction accounting system can be introduced in the future.

Figure 5.1: Methodology of Implementing a Low Carbon Scenario in Putrajaya
5.4 Setting of Research Framework & Methodology

5.4.1 Framework of Putrajaya Green City 2025

The aim of Putrajaya Corporation (PJC) is to create Putrajaya as a Pioneer Green City by the year 2025. In line with this, we the research team studied to identify the important elements which contributes towards the creation and development of a Green City. The findings indicated towards the importance of Low-carbon emission, a lower peak temperature and a reduction in solid waste disposal and generation. In accordance with this, these three environmental targets were set towards the development of Putrajaya Green City 2025:

i) Low Carbon Putrajaya: 60% reduction of Green House Gas emissions
ii) Cooler Putrajaya: -2 Degrees Celsius reduction in Peak temperature
iii) 3R Putrajaya: 50% Reduction of Final Disposal and GHG emission

Each of these environmental targets has its own objective towards achieving their respective target. These targets were set in accordance with two criteria’s:

i) The National Target of Reducing 40% of emission intensity by 202 compared to the levels of 2005
ii) The future development plan of PJC as recorded in the Putrajaya Structure Plan (Laporan Pemeriksaan Rancangan Struktur Putrajaya, June 2009)

1) Low Carbon Putrajaya

The Target of Low-Carbon (LC) Putrajaya is to reduce CO₂ emission intensity (CO₂ emission per economic activity) by 60% compared to the levels in 2007. To achieve this, the current and future levels of CO₂ emission in Putrajaya were calculated using the Community Extended Snapshot tool.
2) **Cooler Putrajaya**

The Target of Cooler Putrajaya is to mitigate urban heat environment and lowering peak temperature to a comfortable level for the residents and workers in Putrajaya. The lowering of the temperature will also assist in reducing the energy demand of cooling devices hence also contributing towards the LC Putrajaya.

3) **3R (Reuse, Recycle, Reduce) Putrajaya**

The Target of 3R Putrajaya is to reduce the solid waste disposed and generated in Putrajaya. The final disposal of solid waste and GHG emission are to be reduced by 50% compared to the levels of 2025 Business as Usual (BaU) scenario.

With regards to the methodology used for this thesis research, only item 1) Low Carbon Putrajaya will be discussed in detail. This is because of the relevance to the implementation of Low Carbon Society.

5.5 **Methodology of Low Carbon Putrajaya - Putrajaya Green City 2025**

5.5.1 **Socio-Economic Scenario**

The socio economic Scenario is drawn up according to the setting of base year for this research of Putrajaya Green City 2025 is set as 2007; this is because of the availability of data from Putrajaya Corporation (PJC). The base year information is obtained mostly from the Draft Laporan Pemeriksaan Rancangan Struktur Putrajaya (June 2009). This document is development planning, and it enabled us to use it to determine the base year information. As for some detailed figures which we were not able to get for Putrajaya as a City, some assumptions were made. The Socio economic assumptions for base year are as seen in Table 4.8.
Table 5.4: Socio-Economic Assumption.

<table>
<thead>
<tr>
<th>Socio-economic indicators</th>
<th>Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>347,700 persons in year 2025.</td>
</tr>
<tr>
<td>Household</td>
<td>79,023 households in year 2025.</td>
</tr>
<tr>
<td>In-coming persons</td>
<td>67,947 persons per day in year 2025.</td>
</tr>
<tr>
<td>Out-going persons</td>
<td>47,672 persons per day in year 2025.</td>
</tr>
<tr>
<td>Floor area</td>
<td>17,229,100 m² in year 2025. (4.5 times compared to 2007 level)</td>
</tr>
<tr>
<td>Employment</td>
<td>164,500 employees in year 2025. (3.7 times compared to 2007 level)</td>
</tr>
<tr>
<td>Economy in Malaysia</td>
<td>Per capita GDP will grow approximately an average of 4.3% per year.</td>
</tr>
<tr>
<td>Passenger transport</td>
<td>It is assumed not to change from year 2007 to 2025 because following factors will cause increase and decrease; [Factor in increase] Increase in leisure &amp; recreation time [Factor in decrease] Aging society, IT society</td>
</tr>
<tr>
<td>generation</td>
<td>Modal share will shift from &quot;Bicycle, Walk&quot; &quot;Motorcycle&quot; to &quot;Automobile&quot; because of economic growth.</td>
</tr>
<tr>
<td>Modal share of passenger</td>
<td>Trip distance of bicycle and walk will decrease because of modal shift to Automobile.</td>
</tr>
<tr>
<td>transport trip</td>
<td>It will increase in proportion to economic activity (7.8 times compared to 2007 level) because number of freight vehicle is assumed to grow with economic activity.</td>
</tr>
<tr>
<td>Average trip distance</td>
<td>Per floor area or per capita energy service demand will increase by 1 to 2.13 times.</td>
</tr>
</tbody>
</table>

5.5.2 Scenario of Future Society Image Description

The population in Putrajaya will increase seven times from 2007 to 2025, to 347,700. The Household number in Putrajaya grows simultaneously with the population. Passenger transport will grow in proportion to the population. Transport demand is different in 2025BaU and 2025CM. This is because Putrajaya will increase the use of public transportation in 2025CM case.

Employment is estimated to increase about 3.7 times in total, while employment in the commercial sector shows very large growth, about 21 times from 4,061 in 2007 to 85,500 in 2025.
To calculate the emission intensity it is important to have the Gross Regional Production (GRP) Putrajaya. However, since this data is not available, as an alternative indicator, "economic activity" is applied here. Economic Activity is defined as "number of employment in Putrajaya multiplied by the Malaysian per capita GDP" and is shown in relative scale compared with base year. As a combined effect of employment growth in Putrajaya and Malaysian expected per capita GDP growth, the economic activity in 2025 is about 7.5 times greater than base year.

5.6  The Community Extended Snapshot tool (C-ExSS)

Community Extended Snapshot Tool (C-ExSS) is an estimation tool to design low-carbon society. This tool illustrates the quantitative future snapshot of the community, and estimates the future environmental load of emissions. C-ExSS is an estimation tool which is used in calculations for low-carbon society in communities or towns which do not have large industrial sector. It illustrates the quantitative future snapshot of the city including energy demand, CO$_2$ emissions and a portfolio of measures to meet the low-carbon target. The features of C-ExSS are;

i. It is a multi-sector static model. The sectors in this study are: Commercial, Public amenities & facilities, Government departments and Residential.

ii. The household sector is classified by income classes, so it is possible to consider household structure change.

iii. The energy demand is driven by population, floor area and the number of employment.

This tool runs on Microsoft Excel. C-ExSS can be run in the Excel file which consists of many worksheets. The flow chart showing the structure of C-ExSS is seen in Figure 5.2. The details of this Model structure are attached to Appendix.
The steps for calculation in the C-ExSS tool are as seen in the Figure 5.3. The first step is to set the target region, base year, estimation case and to identify the units in which these calculators will be calculated in. The second step involves the input of the base year data. The base year for the Putrajaya Green City 2025 study is set at 2007 based on the availability of data and information. In this step the CO₂ emissions in the base year is calculated. The third step is when the CO₂ emission for the future (target year) is estimated. The target year is set as 2025. The Low carbon counter measures are set in the following step and also the abatement cost can be calculated in this level. The fifth and final step is to analyze the results. Identify the factor of reduction of each emission reduction either by sector or by actions.
5.6.1 Framework and Parameter estimation

1) Target Sectors

Four sectors were targeted in this study; “Commercial”, “Public amenities & facilities”, Government departments”, and “Residential” sectors. Table 5.5 below shows detailed classification in each sector.
### Table 5.5: Sector Classifications

<table>
<thead>
<tr>
<th>Sector</th>
<th>Classification</th>
<th>Sector</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>Office/Commercial complex</td>
<td>Parcel A</td>
<td>PM's office</td>
</tr>
<tr>
<td></td>
<td>Shop/Shop office</td>
<td>Parcel B</td>
<td>Prime Minister’s Department</td>
</tr>
<tr>
<td></td>
<td>Hotel</td>
<td>Parcel C</td>
<td>Ministry Of Science, Technology &amp; Innovations &amp; Other Agencies</td>
</tr>
<tr>
<td></td>
<td>Shopping mall</td>
<td>Parcel D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Restaurant</td>
<td>Parcel E</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mix development (housing + commercial)</td>
<td>Parcel F</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Petroleum station</td>
<td>2G1</td>
<td>Ministry of Finance</td>
</tr>
<tr>
<td></td>
<td>Service industry</td>
<td>2G2</td>
<td>Perbendaharaan &amp; Kastam</td>
</tr>
<tr>
<td></td>
<td>Private amenities</td>
<td>2C1</td>
<td>Ministry of the federal territory and welfare of town</td>
</tr>
<tr>
<td></td>
<td>Public kindergarten</td>
<td>2G3</td>
<td>Ministry Of Dosmetic Trade and Consumers Aff</td>
</tr>
<tr>
<td></td>
<td>School</td>
<td>2G4</td>
<td>Ministry Of PlantationsIndustries and Commodities</td>
</tr>
<tr>
<td></td>
<td>Hospital/Clinic</td>
<td>2G5</td>
<td>National Registration Department</td>
</tr>
<tr>
<td></td>
<td>Mosque/Small mosque</td>
<td>2G6</td>
<td>Ministry Of Entrepreneur and Co-operative Development (MEDC)</td>
</tr>
<tr>
<td></td>
<td>Fire Department</td>
<td>2G7</td>
<td>Foreign ministry</td>
</tr>
<tr>
<td></td>
<td>Police station</td>
<td>2G8</td>
<td>Housing loan department</td>
</tr>
<tr>
<td></td>
<td>Neighbourhood Complex</td>
<td>2C10</td>
<td>Election commission</td>
</tr>
<tr>
<td></td>
<td>Food Court (landed)</td>
<td>3G1</td>
<td>Department of Judiciary &amp; Law Affairs</td>
</tr>
<tr>
<td></td>
<td>City service center</td>
<td>3G2</td>
<td>Putrajaya Corporation</td>
</tr>
<tr>
<td></td>
<td>Recycle center</td>
<td>3G3</td>
<td>Palace Of Justice</td>
</tr>
<tr>
<td></td>
<td>Market</td>
<td>3M2+C2+C3</td>
<td>Pilgrimage fund board complex</td>
</tr>
<tr>
<td></td>
<td>Utility</td>
<td>4G1</td>
<td>Ministry Of Agriculture and Agro - Based Industries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4G2</td>
<td>Fisheries Department</td>
</tr>
<tr>
<td></td>
<td>High income</td>
<td>4G3</td>
<td>Ministry Of Natural Resources and Environment</td>
</tr>
<tr>
<td></td>
<td>Middle income</td>
<td>4G4</td>
<td>Ministry Of Youths and Sports</td>
</tr>
<tr>
<td></td>
<td>Low income</td>
<td>4G5</td>
<td>Ministry of road transportation</td>
</tr>
<tr>
<td>Residential</td>
<td></td>
<td>4G7</td>
<td>Attorney General’s Chamber</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4G8</td>
<td>Ministry of rural and regional development</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4G9</td>
<td>Ministry of information, communication, arts, and culture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4G10</td>
<td>Ministry of housing and local government</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4G11</td>
<td>Ministry of women, family, and community development</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5G2</td>
<td>Ministry of higher education, and Ministry of tourism</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other government building</td>
<td></td>
</tr>
</tbody>
</table>
3) **Low-carbon target**

The low-carbon target is to reduce CO\textsubscript{2} emission per economic activity by 60% compared to 2007 level.

### 5.6.2 Estimation of parameters and exogenous variables

The information sources of estimated parameters and exogenous variables are obtained from Putrajaya Corporation. Many of the information are collected from Putrajaya’s master plan (Perbandaran Putrajaya (2009): Laporan Pemeriksaan Draf Rancangan Struktur Putrajaya, Jun 2009) or provided by Planning Department of Putrajaya Corporation. Otherwise, they were estimated based on national data. Implementation of A Dozen Actions towards PGC 2025

### 5.6.3 Calculation Flow of calculation in C-ExSS

The flow of calculation in C-ExSS in base year and target year is shown in Figure 5.4 and Figure 5.5, and Figure 5.6 shows assumptions which affect future calculation.

In target year calculation, estimate household number by dividing population (exogenous) by household size first. Floor area, the number of in-coming/out-going persons for commuting is defined to be exogenous variables.

Energy demands in buildings are obtained by multiplying population and floor area by energy service generation. The sum of population and the number of in-coming persons, which means the number of persons who act in that community, gives passenger transport demand, and the number of employment does freight transport demand. Multiplying those energy service demand, passenger & freight transport demand by fuel share, energy efficiency, and CO\textsubscript{2} emission factor, we can gain energy demand and CO\textsubscript{2} emission. The List of Sets, Parameters and variables
mentioned in the Figures can be found in Appendix…. The formulas used for the C-ExSS calculations are attached in Appendix …..
Figure 5.5: Calculation flow for C-ExSS in target year
Figure 5.6: Assumption for future scenario calculation in C-ExSS
5.6.4 *Future Scenario Assumptions*

The future assumption of society, economy, and energy consumption is described. Given these assumptions, variables in target year were estimated.

Putrajaya’s master plan (Perbandaran Putrajaya, 2009) or Planning Department of Putrajaya Corporation has future development plan. So, when available, their assumptions were applied. If not available, research team made assumptions through discussions.

1) **Demography**

In Perbandaran Putrajaya (2009), population is planned to grow up to 347,700 (7.03 times), so that assumption is used in this study. Household size is assumed not to change from base year (4.4 person/household). That is because average composition of families is considered not to change much, as people move out from Putrajaya with their family after their retirement, and instead, young family move in for job.

2) **Economy**

i) Per capita GDP

Per capita GDP in Malaysia is assumed to grow 4.3% per year, based on future GDP (Department of Statistics, Malaysia, 2010) and population (The economic planning unit, prime minister's department, Putrajaya, 2010) in Malaysia.

ii) Per household expenditure

Per household expenditure is assumed to increase in proportion to per capita GDP in Malaysia.

3) **Commuting**

In-coming/Out-going persons are assumed to increase 5.6 times based on traffic increase ratio from 2008 to 2025 (Perbandaran Putrajaya, 2009, table 2.12.15).
4) Floor area

Total floor area is planned to increase up to 17,187,625 m² (information from Planning Department of PJC), so the assumption is applied in this study. (Floor area of restaurants is computed by the same methodology with base year. See also Table 2.3.)

5) Employment

The total number of employment is assumed to increase up to 164,500 by 2025, based on Perbandaran Putrajaya (2009) and information from Planning Department of PJC. (Allocate it into each classification by the same methodology with base year See also Table 2.4.)

6) Passenger transport

i) Passenger transport generation

There are both increasing and decreasing factors of passenger transport generation in the future, as shown below. Their net effect is not sure, so we considered it is the most reasonable way to assume that the effects will come out even and passenger transport generation will not change.

[Factor in increase] Increase in leisure & recreation time

[Factor in decrease] Aging society, IT society

ii) Modal share (in BaU case)

Because of economic growth, modal share is assumed to shift from walk, bicycles and motorcycles to automobiles.

iii) Average trip distance (in BaU case)

Average trip distance of walk and bicycle will be shortened because of modal shift from walk and bicycle to automobile.
7) **Freight transport**

Freight transport demand is assumed to increases in proportion to economic activity because freight demand is considered to change depending on economic factors and the number of employment.

8) **Building**

Energy service generation of each service is assumed as follows.

i) **Hot water**
   - **Commercial**
     It increases in proportion to sales per floor area because use of hot water is considered to change with output.
   - **Public amenities & facilities, Government departments**
     It increases in proportion to the number of employment per floor area because demand of hot water increases with the number of persons.
   - **Residential**
     It does not change from base year because per person demand of hot water is considered not to be related to economic growth or other indicators.

ii) **Other electric appliances**

   It increases in proportion to per capita GDP in Malaysia because as economy grows, more electric appliances are introduced and also use of them increases.

iii) **Cooling, Cooking, Lighting**

   They do not change from base year because per floor area or per person use of them are considered not to change even if economy grows or other indicators change.
5.6.5 Estimation results

Based on Framework setting and Parameter estimation” and “Future assumptions”, variables in 2007, 2025BaU, and 2025CM were estimated. The main results these calculations will be features in this section.

1) Socioeconomic indicators

The estimation results of the indicators of demography and economy are shown in Table 5.6.

Economic activity is estimated to grow 7.8 times compared to base year.

The estimation results of passenger transport demand and freight transport demand are shown in Table 5.7 and Table 5.8.

Total passenger transport demand is estimated to increase 7.23 times from 2007 to 2025; it is mainly lead by increase of population and In-coming persons. In terms of the share of transport modes, automobile increases from 2007 to 2025BaU because of economic growth. But in
2025CM case, share of bicycle, walk, and public transport modes are increased by countermeasures.

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2025BaU</th>
<th>2025CM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Mill. pass-km/year]</td>
<td>[%]</td>
<td>[Mill. pass-km/year]</td>
</tr>
<tr>
<td>Bicycle, Walk</td>
<td>35</td>
<td>6</td>
<td>97</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>158</td>
<td>27</td>
<td>998</td>
</tr>
<tr>
<td>Automobile</td>
<td>297</td>
<td>51</td>
<td>2495</td>
</tr>
<tr>
<td>Bus</td>
<td>59</td>
<td>10</td>
<td>398</td>
</tr>
<tr>
<td>Rail</td>
<td>36</td>
<td>6</td>
<td>242</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>585</td>
<td>100</td>
<td>4230</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2025BaU</th>
<th>2025CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight transport demand [Mill. t-km/year]</td>
<td>109</td>
<td>851</td>
<td>681</td>
</tr>
<tr>
<td></td>
<td>7.80</td>
<td>6.24</td>
<td>0.80</td>
</tr>
</tbody>
</table>

2) Energy demand and CO₂ emissions

i. **Energy demand**

The estimation result of final energy demand is shown in Table 5.9, and primary energy demand is shown in Table 5.10. The final energy demand in the BaU case is 907.4 ktoe. It is 411.4 ktoe in the CM case, and that means 3.04 times of that in 2007, and 0.45 times of that in the BaU case.
Table 5.9: Estimation results of final energy demand

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>10.11</td>
<td>222.04</td>
<td>151.82</td>
<td>21.95</td>
<td>15.01</td>
<td>0.68</td>
</tr>
<tr>
<td>Public amenities &amp;</td>
<td>10.47</td>
<td>37.25</td>
<td>22.02</td>
<td>3.56</td>
<td>2.10</td>
<td>0.59</td>
</tr>
<tr>
<td>facilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government departments</td>
<td>46.26</td>
<td>82.17</td>
<td>44.97</td>
<td>1.78</td>
<td>0.97</td>
<td>0.55</td>
</tr>
<tr>
<td>Residential</td>
<td>4.43</td>
<td>46.57</td>
<td>32.61</td>
<td>10.51</td>
<td>7.36</td>
<td>0.70</td>
</tr>
<tr>
<td>Passenger transport</td>
<td>57.07</td>
<td>464.46</td>
<td>128.11</td>
<td>8.14</td>
<td>2.24</td>
<td>0.28</td>
</tr>
<tr>
<td>Freight transport</td>
<td>7.06</td>
<td>55.06</td>
<td>31.65</td>
<td>7.80</td>
<td>4.48</td>
<td>0.57</td>
</tr>
<tr>
<td>Total</td>
<td>135</td>
<td>908</td>
<td>411</td>
<td>6.70</td>
<td>3.04</td>
<td>0.45</td>
</tr>
</tbody>
</table>

Table 5.10: Estimation results of primary energy demand

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,339</td>
<td>10,092</td>
<td>5,277</td>
<td>7.5</td>
<td>3.9</td>
<td>0.5</td>
</tr>
</tbody>
</table>

ii. CO₂ emissions

The estimation results of CO₂ emissions are shown in Table 5.11 and those of CO₂ emission per economic activity are shown in Table 5.12. CO₂ emissions increase 7.31 times compared to 2007 in the BaU case, and 3.08 times of that of 2007 in the CM case. In the CM case, it is decreased 58% from that in the BaU case.

CO₂ emission per economic activity in BaU case is 0.94 when set that in 2007 to be 1. And in CM case, it is 0.40. It means CO₂ emission per economic activity is reduced 60% compared to 2007.
Table 5.11: Estimation results of CO\textsubscript{2} emissions

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>65</td>
<td>1435</td>
<td>769</td>
<td>22.23</td>
<td>11.92</td>
<td>0.54</td>
</tr>
<tr>
<td>Public amenities &amp; facilities</td>
<td>67</td>
<td>240</td>
<td>112</td>
<td>3.60</td>
<td>1.68</td>
<td>0.47</td>
</tr>
<tr>
<td>Government departments</td>
<td>180</td>
<td>363</td>
<td>139</td>
<td>2.01</td>
<td>0.77</td>
<td>0.38</td>
</tr>
<tr>
<td>Residential</td>
<td>23</td>
<td>266</td>
<td>150</td>
<td>11.40</td>
<td>6.42</td>
<td>0.38</td>
</tr>
<tr>
<td>Passenger transport</td>
<td>161</td>
<td>1314</td>
<td>368</td>
<td>8.14</td>
<td>2.28</td>
<td>0.28</td>
</tr>
<tr>
<td>Freight transport</td>
<td>20</td>
<td>156</td>
<td>89</td>
<td>7.80</td>
<td>4.45</td>
<td>0.57</td>
</tr>
<tr>
<td>Carbon sink (Tree planting)</td>
<td>-</td>
<td>-</td>
<td>-35</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>516</td>
<td>3772</td>
<td>1591</td>
<td>7.31</td>
<td>3.08</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Table 5.12: Estimation results of CO\textsubscript{2} emission per economic activity (year 2007=1)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>0.94</td>
<td>0.40</td>
<td>0.94</td>
<td>0.40</td>
<td>0.42</td>
</tr>
</tbody>
</table>

3) Low-carbon countermeasures

It shows that countermeasures for passenger transport contribute to CO\textsubscript{2} emission reduction the most (939ktCO\textsubscript{2}), and second largest contributor is those for commercial sector (452ktCO\textsubscript{2}). Please see also Appendix 7.11~7.15 for the list of introduced low-carbon measures with their performance, diffusion rate, CO\textsubscript{2} emission reduction, and initial cost. Those countermeasures are categorized to actions, and emission reduction of each action is estimated. Please see also Chapter 5 for actions.
### CO₂ Emission Reduction by Countermeasure Types

<table>
<thead>
<tr>
<th>Category</th>
<th>Countermeasure Type</th>
<th>CO₂ Emission Reduction [ktCO₂]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>BEMS/Building insulation/Energy saving behavior</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>Introduction of energy-efficient appliances</td>
<td>344</td>
</tr>
<tr>
<td></td>
<td>Photovoltaic power generation</td>
<td>5</td>
</tr>
<tr>
<td>Public amenities &amp; facilities</td>
<td>BEMS/Building insulation/Energy saving behavior</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Introduction of energy-efficient appliances</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Photovoltaic power generation</td>
<td>2</td>
</tr>
<tr>
<td>Government departments</td>
<td>BEMS/Building insulation/Energy saving behavior</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>Introduction of energy-efficient appliances</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td>Photovoltaic power generation</td>
<td>37</td>
</tr>
<tr>
<td>Residential</td>
<td>HEMS/House insulation</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Introduction of energy-efficient appliances</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Photovoltaic power generation</td>
<td>6</td>
</tr>
<tr>
<td>Passenger transport</td>
<td>Modal shift</td>
<td>286</td>
</tr>
<tr>
<td></td>
<td>Shorter trip distance</td>
<td>259</td>
</tr>
<tr>
<td></td>
<td>Introduction of low-emission vehicles</td>
<td>395</td>
</tr>
<tr>
<td>Freight transport</td>
<td>Efficient logistics</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Introduction of low-emission vehicles</td>
<td>40</td>
</tr>
<tr>
<td>Others</td>
<td>Central power generation</td>
<td>333</td>
</tr>
<tr>
<td></td>
<td>Carbon sink (Tree planting)</td>
<td>35</td>
</tr>
</tbody>
</table>

**Figure 5.7: CO₂ emission reduction by countermeasure types**
5.7 Introduction of six (6) Low Carbon Actions towards PGC 2025

5.7.1 Action, Sub-action, Program

During the Focus Group Discussions which were held in Putrajaya in the form of Workshops. Participants of the Workshop together with Putrajaya Corporation and the project team members brainstormed to identify the actions, sub-actions and Programs that will assist in lowering CO2 emission base on the calculations shown above. The definition of Action, Sub-action, and Program are as follows:

2) Action

There are twelve actions which have been identified by the task force members for the CO2 emission reduction, creating a cooler Putrajaya and also a 3R Putrajaya. These 12 actions names function as the keywords or headings that call out towards the achievement of Putrajaya as Green city. There are six (6) actions towards a Low-carbon Putrajaya, two (2) actions towards a Cooler Putrajaya, three (3) actions towards 3R Putrajaya and one (1) action which is a collaboration of all three environmental targets.

3) Sub-Action

The sub-actions are the general policy measures which can be identified in each of the twelve actions to further detail out the action. These sub-actions were decided thru the workshop which was held in Putrajaya.
4) Program

The programs are a list of activities which can be conducted or implemented through each of the sub-actions introduced. These programs function as a list of detailed activities which have direct or indirect effect towards the success of each Action.

5.7.2 Estimation of GHG emission reduction

The methodology of estimating GHG emission reduction by each sub-action is shown here. GHG emission reduction by each sub-action was estimated by allocating emission reduction by countermeasures to sub-actions.

5.7.3 List of Actions and amount of CO\textsubscript{2} emission reduction contribution

Below listed are the Action, sub-actions and the amount of CO\textsubscript{2} emission reduction each sub-action contributes towards the overall CO\textsubscript{2} reduction in Putrajaya. The details of proposed sub-action with the list of programs in all these six (6) actions which can be implemented by the Local Authority- PJC can be found in Appendix 21-25.
1) **Action 1**

CO₂ emission reduction by Action1 “Integrated City Planning & Management” and corresponding countermeasures are shown in Table 5.13. This action is related to modal shift and shortening of trip distance by city development.

<table>
<thead>
<tr>
<th>Sub-action</th>
<th>Methodology of allocating emission reduction</th>
<th>CO₂ emission reduction [ktCO₂]</th>
<th>Contribution in the Action [%]</th>
<th>Contribution in total reduction [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1 Make cycling as preferred transport option (Bikeable City)</td>
<td>Contribution of &quot;(24)Pedestrian-friendly city development&quot; in 90% of reduction by</td>
<td>53</td>
<td>17%</td>
<td>2%</td>
</tr>
<tr>
<td>1-2 Make walking as preferred transport option (Walkable City)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-3 Enhance mixed-use and diversified development</td>
<td>Contribution of &quot;Shorter trip distance&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-4 Residential Layout Planning</td>
<td>Contribution of (26)Introduction of new rail line, (27)Mixed use development, (28)ITS</td>
<td>259</td>
<td>83%</td>
<td>11%</td>
</tr>
<tr>
<td>Introduce Low Carbon Planning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-5 Control &amp; Development Plans &amp; Practices</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-6 Allocate Land for Solid Waste Management Facilities.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Management Plan</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>312</strong></td>
<td><strong>100%</strong></td>
<td><strong>13%</strong></td>
</tr>
</tbody>
</table>

2) **Action 2**

CO₂ emission reduction by Action2 “Low-carbon Transportation” and corresponding countermeasures are shown in Table 5.14. In this action, CO₂ emission is reduced by efficiency improvement of vehicle and modal shift to public transportation.
Table 5.14: CO₂ emission reduction by Action 2

<table>
<thead>
<tr>
<th>Sub-action</th>
<th>Methodology of allocating emission reduction</th>
<th>CO₂ emission reduction [ktCO₂]</th>
<th>Contribution in the Action [%]</th>
<th>Contribution in total reduction [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encourage the Use of Low-carbon emission vehicles 2-1</td>
<td>It is assumed that 90% of emission reduction by &quot;Efficiency improvement of motorcycles, automobiles, buses&quot; is lead by Efficiency improvement of vehicles and 10% is by ITS. So emission reduction of this sub-action is: (90% of Contribution of &quot;(17)High efficiency internal combustion vehicle&quot;&quot;(18)Hybrid vehicle&quot;&quot;(19)Electric vehicle&quot;&quot;(20)High efficiency natural gas vehicle&quot;&quot;(21)High efficiency natural gas bus&quot; in &quot;Efficiency improvement of motorcycles, automobiles, buses&quot;) + (Contribution of &quot;(16)High efficiency motorcycle&quot;&quot;(22)Efficiency improvement of trains&quot; in &quot;Efficiency improvement of motorcycles, automobiles, buses&quot;)</td>
<td>362</td>
<td>62%</td>
<td>15%</td>
</tr>
<tr>
<td>Implement Integrated Transportation System 2-2</td>
<td>It is assumed that 90% of emission reduction by &quot;Efficiency improvement of motorcycles, automobiles, buses&quot; is lead by Efficiency improvement of vehicles and 10% is by ITS. So emission reduction of this sub-action is: (10% of Contribution of &quot;(17)High efficiency internal combustion vehicle&quot;&quot;(18)Hybrid vehicle&quot;&quot;(19)Electric vehicle&quot;&quot;(20)High efficiency natural gas vehicle&quot;&quot;(21)High efficiency natural gas bus&quot; in &quot;Efficiency improvement of motorcycles, automobiles, buses&quot;)</td>
<td>61</td>
<td>11%</td>
<td>3%</td>
</tr>
<tr>
<td>Implement Intelligent Transportation System 2-3</td>
<td>(10% of Contribution of &quot;(17)High efficiency internal combustion vehicle&quot;&quot;(18)Hybrid vehicle&quot;&quot;(19)Electric vehicle&quot;&quot;(20)High efficiency natural gas vehicle&quot;&quot;(21)High efficiency natural gas bus&quot; in &quot;Efficiency improvement of motorcycles, automobiles, buses&quot;) + (10% of &quot;Modal shift&quot;)</td>
<td>61</td>
<td>11%</td>
<td>3%</td>
</tr>
<tr>
<td>Encourage Transit Oriented Development (TOD) 2-4</td>
<td>(90% of contribution of &quot;(25)Introduction of new rail line&quot;&quot;(23)Enhancement of bus system&quot; in &quot;Modal shift&quot;)</td>
<td>159</td>
<td>27%</td>
<td>7%</td>
</tr>
</tbody>
</table>

**Total**                                           | 582                         | 100%                        | 24%                           |
3) Action 3

CO$_2$ emission reduction by Action3 “Cutting-Edge Sustainable Buildings” and corresponding countermeasures are shown in Table 5.15. This action contributes to emission reduction through saving energy in Commercial, Public amenities & facilities, and Government departments sector.

<table>
<thead>
<tr>
<th>Sub-action</th>
<th>Methodology of allocating emission reduction</th>
<th>CO$_2$ emission reduction [ktCO$_2$]</th>
<th>Contribution in the Action [%]</th>
<th>Contribution in total reduction [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-3 Eco friendly Building Materials</td>
<td>Contribution of &quot;(9)Building insulation&quot; in Commercial, Public amenities &amp; facilities, and Government departments sector.</td>
<td>50</td>
<td>7%</td>
<td>2%</td>
</tr>
<tr>
<td>3-4 To integrate Recycling facilities in building designs.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>3-5 Impose Building Rating System to all Buildings</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>666</td>
<td>100%</td>
<td>28%</td>
</tr>
</tbody>
</table>

* CO$_2$ emission reduction by this Sub-action includes the effect of energy saving behavior.

4) Action 4

CO$_2$ emission reduction by Action4 “Low Carbon Lifestyle” and corresponding countermeasures are shown in Table 5.16. This action contributes to emission reduction through saving energy in Residential sector.
Table 5.16: CO\textsubscript{2} emission reduction by Action4

<table>
<thead>
<tr>
<th>Sub-action</th>
<th>Methodology of allocating emission reduction</th>
<th>CO\textsubscript{2} emission reduction [ktCO\textsubscript{2}]</th>
<th>Contribution in the Action [%]</th>
<th>Contribution in total reduction [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-1 Energy Efficient Appliances in Homes.</td>
<td>Efficiency improvement &amp; fuel shift of &quot;Cooling&quot;, &quot;Hot water&quot;, &quot;Cooking&quot;, &quot;Lighting&quot;, and &quot;Other electriappliances&quot; ((1)–(7)) in Residential sector.</td>
<td>55</td>
<td>77%</td>
<td>2%</td>
</tr>
<tr>
<td>4-2 HEMS (Home Energy Management System)*</td>
<td>Contribution of &quot;(14)HEMS&quot;&quot;(10)Energy saving behavior&quot;&quot;(15)House insulation&quot; in Residential sector</td>
<td>16</td>
<td>23%</td>
<td>1%</td>
</tr>
<tr>
<td>4-3 Promoting organic / low carbon products</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4-4 To integrate Recycling facilities in High rise residential building designs.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>71</td>
<td>100%</td>
<td>3%</td>
</tr>
</tbody>
</table>

* CO\textsubscript{2} emission reduction by this Sub-action includes the effect of energy saving behavior.

5) Action 5

CO\textsubscript{2} emission reduction by Action5 “More and More Renewable Energy” and corresponding countermeasures are shown in Table 5.17. Emission reduction in this action is achieved by Photovoltaic power generation.

Table 5.17: CO\textsubscript{2} emission reduction by Action5

<table>
<thead>
<tr>
<th>Sub-action</th>
<th>Methodology of allocating emission reduction</th>
<th>CO\textsubscript{2} emission reduction [ktCO\textsubscript{2}]</th>
<th>Contribution in the Action [%]</th>
<th>Contribution in total reduction [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-1 Photovoltaic power generation and utilisation</td>
<td>Contribution of &quot;(12)Photovoltaic power generation&quot;</td>
<td>50</td>
<td>100%</td>
<td>2%</td>
</tr>
<tr>
<td>5-2 Alternative fuel source from Solar assisted power generation</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5-3 Explore possibilities of utilizing Solar Thermal</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5-4 Biomass production &amp; utilisation</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5-5 Research &amp; Development for RE for Local consumption</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>50</td>
<td>100%</td>
<td>2%</td>
</tr>
</tbody>
</table>
6) Action 6

CO$_2$ emission reduction by Action6 “The Green Lung of Putrajaya” and corresponding countermeasures are shown in Table 5.18. Carbon sink by tree planting contributes to this action.

<table>
<thead>
<tr>
<th>Sub-action</th>
<th>Methodology of allocating emission reduction</th>
<th>CO$_2$ emission reduction [ktCO$_2$]</th>
<th>Contribution in the Action [%]</th>
<th>Contribution in total reduction [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-1 To develop an Action Plan for urban reforestation</td>
<td>Contribution of &quot;(33) Carbon sink (Tree planting)&quot;</td>
<td>35</td>
<td>100%</td>
<td>1%</td>
</tr>
<tr>
<td>6-2 To ensure connectivity between fragmented forests</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6-3 To encourage Green infrastructure</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6-4 To develop a detailed Tree Inventory Database</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6-5 Innovation and Research &amp; Development</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>35</strong></td>
<td><strong>100%</strong></td>
<td><strong>1%</strong></td>
<td><strong>1%</strong></td>
</tr>
</tbody>
</table>
5.8 The Structure of Focus Group Discussions (FGD) in Putrajaya

To obtain the results as mentioned in Section 5.7; the list of actions, sub-action and programs are identified by having Focus Group Discussion (FGD). For the reason of this research, two FGD sessions were held in Putrajaya Corporation. The structure of FGD I is as seen in Figure 5.8.

There are three main session in this FGD; 1) preparations before the FGD, 2) events during FGD and 3) output/results after the FGD session. The Preparations before the FGD event is a very important session. This is when the team members organize as to how the whole event will take place and if it will be a success or not. The first thing to do is to identify the objective of having this FGD. For PGC 2025 research, we conducted this study to:

i. Identify the availability of data; in Putrajaya Corporation (PJC) and the other Government agencies in Putrajaya.

ii. To learn and understand the current and future plans PJC has for the development in Putrajaya.

iii. To set the target for this study. In this case; to set the Environmental Targets as mentioned in Section 5.5 of this thesis.

Once the objective is set, the project team which consists of both the Local Authority; who is PJC here, and the team of Researchers meet together and identify the persons who will be moderating the FGD session. A Moderator is needed to make sure the Objective is met and the FGD does not go beyond time limitations, and out of topic.

Since FGD was an in-house event, we had it at the office building in PJC and was attended by about 20 members from the PJC. They were from all the various departments in PJC. The refreshment (food and drinks) for the session was provided by PJC. It is important to have these
During the FGD session the important to have a good moderator who will be able to keep time and keep the whole session in focus. And it is also important for a secretary in the project team to record the minutes of this session.

Planning for this FGD took about 1 month. This was because; we needed to invite researchers from Japan to attend this event in Malaysia. Inviting the in-house participants for this FGD is not a problem, because this is part of PJC’s events. The outcome of this first FGD is as seen in

Figure 5.8: Structure of Focus Group Discussion I (FGD I) for PGC 2025

During the FGD session the important to have a good moderator who will be able to keep time and keep the whole session in focus. And it is also important for a secretary in the project team to record the minutes of this session.

Planning for this FGD took about 1 month. This was because; we needed to invite researchers from Japan to attend this event in Malaysia. Inviting the in-house participants for this FGD is not a problem, because this is part of PJC’s events. The outcome of this first FGD is as seen in
Figure 5.9, this is a leaflet a one sheet A3 size paper printed on both sides introducing this project. Having this leaflet is a good progress. This is because it is easier to introduce the targets and goal of this project to other stakeholders. And it is the first output of this research.

Besides this leaflet, the information gathered from this FGD will be the data source for the researchers to continue the collection of data for the Running of the C-ExSS tool to calculate the CO$_2$ emissions in Putrajaya.

![Figure 5.9: The PGC 2025 Leaflet](image)

The FGD II session structure is as seen in Figure 5.10. This FGD II is a more detailed and longer event. For this reason we had a 2 day event. The preparations towards this event took about three months. This is because,

a) The Leaflet and other materials need to be prepared
b) The preliminary results from C-ExSS is needed to be computed

c) Invitations have to be sent out by PJC to other Stakeholders (Government Offices, Non-Governmental Agencies, Private companies, Service providers, resident’s representatives and others). The list of Participants who attended this FGD II us as seen in Appendix 28-29

d) To select facilitators for the discussion sessions.

e) To prepare a materials for the facilitators and participants. This will be a guide for them to have the brainstorming sessions about the Actions and enable them to present a good list of sub-actions and programs.

The FGD II event is divided into two days. Day one; where the participants are introduced to the project and the objectives. They are also broken into smaller groups of 10-12 members in each group for the brainstorming session. These teams are broken into based on the expertise of the participants and the relevant action they think they can contribute ideas towards. The second half of day one is spent on brainstorming session (a workshop session). Participants are given a drawing board to put out their ideas and suggestions. Day two is when each group is given about 30 minutes to put forward their ideas for sub-actions and programs which will be suitable to be carried out in Putrajaya.

The results from this FGD II are then incorporated into the C-ExSS model to estimate the amount of CO$_2$ emission reduction each action would contribute. This is as discussed in the earlier section of this thesis. As results of this research, this thesis is written, and also a brochure to introduce and promote this research is published as seen in Figure 5.11.

The good outcome of this research is as seen in Appendix 30 where the Government rules out for all Government buildings to have 24 degrees Celsius air-conditioning temperature to be set. This
is the kind of results we are expecting out of this research and study. We want these Actions to be implemented and further move as policies in Malaysia.

Figure 5.10: Structure of Focus Group Discussion II (FGD II) in for PGC 2025

Figure 5.11: The Brochure introducing the Findings from the PGC 2025 Research
Conclusion of Low Carbon Society Research in Putrajaya

As a conclusion of the Low Carbon Society research which was conducted in Putrajaya was a success. With the quantification tool of Community Extended Snapshot tool, the targeted CO$_2$ emission intensity and energy demand was calculated. A reduction of 60% in CO$_2$ emission intensity in 2025 compared to the levels in 2007 was able to be achieved with Low Carbon actions. With Focus Group Discussions (FGDs) and the corporation from various stakeholders alongside Putrajaya Corporation, we were able to come up with the six Low Carbon Actions which can be implemented in Putrajaya.

The results from this research were successfully presented to the decision makers in Putrajaya including the President of Putrajaya. This research received good feedback and the actions suggested and proposed here in this research will be implemented in Putrajaya.
6 CONCLUSION

6.1 Conclusion of the Research

As a conclusion of this research, the objectives of this research were able to be achieved. This research achieved the following:

i. A comprehensive methodology of implementing Low Carbon Society (LCS) scenarios by a Local Authority.

ii. This methodology shows consistency and feasibility when it was successfully implemented in two study areas:
   a. Iskandar Malaysia
   b. Putrajaya

In Iskandar Malaysia study area, the two targets which were set at the beginning of the research were able to be achieved. The targets are as follows:

i. 30% reduction of per capita CO$_2$ emission from 2025BaU to 2025CM (with counter measure)

ii. 50% reduction of CO$_2$ emission intensity from 2005 to 2025CM

The CO$_2$ emission per capita was reduced from 9.89 t-CO$_2$/person (2025BaU) to 6.80 t-CO$_2$/person (2025CM). This accounts to about 30% reduction. As for the CO$_2$ emission intensity (CO$_2$/GDP), from 2005 the level of 0.93kt-CO$_2$/USD is reduced by 50% to achieve 0.46kt-CO$_2$/USD in 2025CM.

In the implementation methodology section this results were discussed with the policy makers in Iskandar Malaysia, and the results were presented in the brochure. The Focus Group Discussion
sessions were not held during the time frame of this research, however the LCS activities in IM are currently on-going and the FGD sessions are to be held in 2012.

As a conclusion for the research conducted in Putrajaya, a reduction of 60% in CO₂ emission intensity in 2025 compared to the levels in 2007 was able to be achieved with Low Carbon actions. With Focus Group Discussions (FGDs) and the corporation from various stakeholders alongside Putrajaya Corporation, we were able to come up with the six Low Carbon Actions which can be implemented in Putrajaya. The results from this research were successfully presented to the decision makers in Putrajaya including the President of Putrajaya. This research received good feedback and the actions suggested and proposed here in this research will be implemented in Putrajaya.

Therefore it can be concluded that the methodology proposed here in this research is consistant and feasible and it can be used in the implementation of Low Carbon Society Cities and Regions in Malaysia.

6.2 Future Direction

The current research has introduced a Methodology to implement Low Carbon Society (LCS) in Iskandar Malaysia and Putrajaya. The next step of research can be, to incorporating this methodology with other suitable methodologies towards developing a roadmap for Low Carbon Society for cities and regions in Malaysia.
BIBLIOGRAPHY


ACKNOWLEDGEMENT

“Success is the good fortune that comes from aspiration, desperation, perspiration and inspiration.” --Evan Esar

This three and a half year journey here at Kyoto University was a dream which probably began when I was the age of six and wanted to have the initials “Dr.” to be printed before my name. Had I paid a bit more attention during my biology, and chemistry classes during my schooling days I would have gone into the medical field to pursue that dream. Never-the-less, as Confucius once said; “When it is obvious that the goals cannot be reached, don’t adjust the goals, adjust the action steps.” I guess that was how I reached this glorious day when I am penning out my thank you list to all the many-many people who have paved my way towards achieving my PhD and writing this thesis.

First and for most, the two wonderful people who have been the reason I have come this far in my life. My very dear parents; my Appa; Mr. K.Simson and Amma; Mrs. Esther Moses who have been my strength, guide and the very first persons to teach me to work really hard without giving up to achieve my dreams. Appa & amma, your support and prayers sustained me and held me when I felt week, and your love and guidance taught me to achieve my dreams. Many thank you also goes to my dearest sister; Joyce Simson, the person who held my hands and sat next to me in class on my first day in Kindergarten and ever since then you have always been next to me all my life, through all the ups and downs. For always encouraging me to trust in God and to believe in myself. I would not have been able to leave Malaysia and come here to Japan to pursue my dream, had it not been for you. To my brother-in-law, Patrick Joseph, thank you for being the strength behind my sister and parents. You are a wonderful friend and brother, who always made me laugh even during the toughest of times.
"One looks back with appreciation to the brilliant teachers, but with gratitude to those who touched our human feelings. The curriculum is so much necessary material, but warmth is the vital element for the growing plant and for the soul of the child." -- Carl Jung

To all my teachers and educators who had been my guide at many different points in my life. Thank you for the gift of knowledge which you shared with me. It has opened a whole new world of opportunities which has challenged me to discover more about life and its many beauties. My sincere thanks and gratitude goes out to all my lecturers here at Kyoto University who have been my mentor and guide throughout these three years. To my supervisor Prof. Yuzuru Matsuoka; for your wise counsel and patience with me, your professional competence and excellent suggestions have given me inspirations and helped me throughout my research. To Prof. Gakuji Kurata who has also been my support during my research work and writing of this thesis. To Reina Kawase Sensei, who made my days here in Kyoto University a lot easier, from the time you helped me move in to my apartment to the countless times you helped me with the administration matters. Thank you also for being a wonderful teacher who helped me with my research work and encouraging me never to give up. To Dr. Kei Gomi, for being one of my best teachers who taught me the tools for research work, thank you for your patience and all the guidance. It may have been difficult to finish this thesis if not for your consistent guidance and push. To Ms. Emiko Hatanaka, for being a wonderful friend and help during my student life here, you have been a source of laughter and encouragement. Thank you for doing all the difficult paperwork and assisting with the organizing of meetings for my research work.

My thanks and appreciation also goes out to my lecturers in University Teknologi Malaysia. Especially to The Late Prof. Supian Ahmad; Dean of the Faculty of Built Environment in UTM for recommending me to pursue my PhD here in Kyoto University. If not for you sir, I will not
be here today. I also extend my thanks and gratitude to Prof. Ho Chin Siong for believing in me and guiding me towards making the move to further my studies here in Kyoto University. For your never ending support me during my research work and co-writing many papers with me. Thank you for your continuous support, words of encouragement and, professional approach which made my research work on the Malaysian side a lot smoother.

This research would not have been successful if not for the organizations such as Iskandar Regional Development Authority (IRDA) and Putrajaya Corporation (PJC). My special thanks go out to the members in IRDA who have been very kind and assisted a lot with my research work which was carried out in Iskandar Malaysia. Namely Tuan Haji Ismail Ibrahim, Mr. Boyd Dionysius Joeman, and his research team in IRDA. Special thanks also go out to the members in PJC; namely, Mr. Omairi bin Hashim, Mr. Azizi Ahmad Termizi, Mr. Azhar bin Othman Ms. Wang Tze Wee and the research team in PJC. Thank you for your collaboration and assistance towards making this research work a success.

"Without friends no one would choose to live, though he had all other goods."

- Aristotle

My friends have been my pillar of strength throughout my research work days. To my friends here in Matsuoka Laboratory (Oct 2008-2012), all of you have been the silver lining in my cloud. Even though we come from different backgrounds, cultures and countries we all became one under the bonds of friendship. Thank you for tolerating and teaching me Japanese Language which I am yet to master, for the many lab parties, lab outing and hiking trips together. All of you have made my life here in Kyoto a lot more colorful and vibrant. To my many-many other friends here in Kyoto, you who have helped me keep my sanity in check with the constant shopping trips and sushi outings, thank you. To my special friends here in Japan and from back
home in Malaysia, thank you for all the phone calls and emails to make sure I complete my studies successfully. Last but not least, I want to thank my friends from St. Agnes Church here in Kyoto and my church back home in Malaysia, for your constant prayers and support, and for being my family here in Kyoto and always looking out me. Last but not least, I Thank God the Almighty for giving me this opportunity of a lifetime here in Kyoto University.

"Life is no brief candle for me. It is a sort of splendid torch which I have got hold of for the moment and I want to make it burn as brightly as possible before handing it on to future generations."

-- George Bernard Shaw
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Appendix 1: List of socioeconomic indicators used for this study (1/2)

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Appendix 2: List of socioeconomic indicators used for this study (2/2)

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<tr>
<td></td>
<td>Load tonnage per vehicle per trip</td>
<td>t/vehicle/trip</td>
<td>Fulton, L. and G. Eads (2004), p.48</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Freight vehicle</td>
<td>2.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTG</td>
<td>Freight transport generation per output</td>
<td>703 unit RM</td>
<td>estimated by freight transport volume</td>
<td></td>
</tr>
<tr>
<td>FTS</td>
<td>Modal share</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Freight railways</td>
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<td></td>
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<tr>
<td></td>
<td>Freight vehicle</td>
<td>0.997</td>
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<td></td>
</tr>
<tr>
<td>FTAD</td>
<td>Average trip distance</td>
<td>km/trip</td>
<td>estimated by Department of Statistics, Malaysia (2006c), annual mileage per vehicle, and load tonnage per vehicle per trip</td>
<td></td>
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<tr>
<td></td>
<td>Freight railways</td>
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<td>Freight vehicle</td>
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<td>FTD</td>
<td>Freight transport volume</td>
<td>mil t-km</td>
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<td></td>
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<td></td>
<td>Freight railways</td>
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## Appendix 3: Iskandar Malaysia 2005 Energy balance table (final demand sector)

<table>
<thead>
<tr>
<th>Industry</th>
<th>Coal</th>
<th>Petroleum Products (total)</th>
<th>Natural gas</th>
<th>LNG</th>
<th>Renewables</th>
<th>Electricity</th>
<th>Total</th>
<th>Ratio of All Sector</th>
</tr>
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<tr>
<td></td>
<td></td>
<td>Gasoline Naphtha Jet Fuel Kerosene Diesel Oil Heavy Oil Lubricating Oil LPG Petrol. Coke Petrol. Coke</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-manufacturing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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</tr>
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<td>Construction</td>
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<td>0.0</td>
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<td>0.2</td>
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<td>64%</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
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<td>Electric and Electronic</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>14.5</td>
<td>65%</td>
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<tr>
<td>Non-Metallics</td>
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<td></td>
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<td>436.2</td>
<td>53%</td>
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<td></td>
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<td>Transport</td>
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<td>Passenger vehicle</td>
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<td>0.0</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>12.9</td>
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</tr>
<tr>
<td>Rail</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>39%</td>
</tr>
<tr>
<td>Ship</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>39%</td>
</tr>
<tr>
<td>Aviation</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>39%</td>
</tr>
<tr>
<td>Freight</td>
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<td>568.3</td>
<td>352.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>216.2</td>
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</tr>
<tr>
<td>Rail</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>39%</td>
</tr>
<tr>
<td>Ship</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>39%</td>
</tr>
<tr>
<td>Aviation</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>39%</td>
</tr>
<tr>
<td>Total</td>
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<td>925.0</td>
<td>573.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>351.8</td>
<td>39%</td>
</tr>
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<td>1,703.6</td>
<td>575.0</td>
<td>0.0</td>
<td>0.0</td>
<td>3.8</td>
<td>788.1</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: Iskandar Malaysia 2005 Energy balance table (final demand sector)
Appendix 4: Iskandar Malaysia 2005 IO table transactions valued at producer’s price (1/2)

| Category                          | Agriculture | Mining | Beverages | Food Products and Beverages | Chemicals and Chemical Products | Electric and Electronic Products and Machinery | Fabricated Metal Products and Machinery | Other Non-Metallic Products | Rubber and Plastics Products | Construction | Transport related | Wholesale and Retail | Tourism and Hospitality | Public Administration | Total Intermediate Input | Compensation of Employee | Operating Surplus | Other Value Added | Total Value Added | Total Input (Domestic Production) |
|-----------------------------------|-------------|--------|-----------|--------------------------------|---------------------------------|----------------------------------------|----------------------------------------|-------------------------------|--------------------------------|---------------|-------------------|---------------------|----------------------------|------------------------|-------------------------|---------------------|----------------------|------------------------|------------------------|
| Agriculture                       | 175         | 0      | 1,686     | 232                            | 5                               | 14                                     | 561                                    | 472                           | 7                             | 2                          | 9                   | 1,059               |
| Mining                            | 0           | 0      | 0         | 139                            | 2                               | 107                                    | 83                                     | 252                           | 214                            | 0                          | 1                   | 0                   |
| Food Products and Beverages       | 105         | 0      | 3,673     | 518                            | 6                               | 2                                      | 17                                     | 3                             | 6                             | 1                          | 7                   | 2,283               |
| Chemicals and Chemical Products   | 74           | 0      | 250       | 2,063                          | 833                            | 506                                    | 291                                    | 910                           | 54                            | 13                         | 19                  | 53                  |
| Electric and Electronic Products  | 11           | 0      | 0         | 2                              | 1,343                           | 7,548                                  | 97                                     | 152                           | 306                           | 35                         | 15                  | 30                  |
| Machinery                         | 43           | 0      | 166       | 196                            | 2,963                           | 6,442                                  | 257                                    | 1,302                         | 429                           | 109                        | 119                 |                     |
| Other Non-Metallic Products       | 17           | 0      | 247       | 116                            | 653                            | 331                                    | 1,282                                  | 79                            | 2,141                          | 17                          | 121                 | 111                 |
| Rubber and Plastics Products      | 135          | 0      | 544       | 469                            | 236                            | 352                                    | 390                                    | 746                           | 103                           | 824                        | 174                 | 95                  |
| Construction                      | 17           | 0      | 36        | 124                            | 61                             | 116                                    | 44                                     | 67                            | 243                           | 51                          | 147                 | 82                  |
| Transport related                 | 14           | 0      | 120       | 79                             | 186                            | 205                                    | 91                                     | 43                            | 109                           | 2,127                       | 239                 | 138                 |
| Wholesale and Retail              | 61           | 0      | 288       | 325                            | 1,817                           | 1,776                                  | 231                                    | 306                           | 335                           | 172                        | 47                  | 297                 |
| Tourism and Hospitality           | 2            | 0      | 12        | 18                             | 49                             | 41                                     | 16                                     | 14                            | 35                            | 418                        | 400                 | 156                 |
| Professional and Business         | 12           | 0      | 77        | 136                            | 190                            | 268                                    | 69                                     | 54                            | 388                           | 355                        | 1,195               | 926                 |
| Medical and Education             | 54           | 0      | 112       | 124                            | 151                            | 147                                    | 35                                     | 116                           | 55                            | 109                        | 462                 | 202                 |
| Other Services                    | 10           | 0      | 244       | 197                            | 231                            | 319                                    | 118                                    | 132                           | 64                            | 170                        | 394                 | 546                 |
| Public administration             | 0            | 0      | 3         | 0                              | 0                               | 0                                      | 0                                      | 1                             | 1                             | 0                          |                     |                     |
| Total intermediate input          | 731          | 0      | 7,548     | 4,738                          | 21,729                         | 18,173                                 | 3,567                                  | 5,715                         | 4,433                         | 4,723                       | 3,340               | 6,099               |
| Compensation of Employee          | 202          | 0      | 471       | 386                            | 1,489                          | 1,042                                  | 722                                    | 258                           | 1,227                         | 1,122                       | 1,695               | 1,183               |
| Operating Surplus                 | 924          | 0      | 1,271     | 1,482                          | 3,542                          | 2,685                                  | 1,057                                  | 1,097                         | 609                           | 1,342                       | 6,228               | 1,921               |
| Other value added                 | 3            | 0      | 29        | 45                             | 44                             | 132                                    | 31                                     | 26                            | 46                            | 39                          | 94                  | 58                  |
| Total value added                 | 1,129        | 0      | 1,771     | 1,913                          | 5,075                          | 3,859                                  | 1,811                                  | 1,381                         | 1,882                         | 2,503                       | 8,018               | 3,162               |
| Total input (domestic production) | 1,860        | 0      | 9,228     | 6,651                          | 26,803                         | 22,032                                 | 5,378                                  | 7,095                         | 6,315                         | 7,226                       | 11,358              | 9,261               |
## Appendix 5: Iskandar Malaysia 2005 IO table transactions valued at producer’s price (2/2)

|                      | Agriculture | Mining | Food Products and Bevarages | Chemicals and Chemical Products | Electric and Electronic Products and Machinery | Fabricated Metal Products and Machinery | Other Non-Metallic | Rubber and Plastics Products | Construction | Transport related | Wholesale and Retail | Tourism and Hospitality | Professional and Business | Medical and Education | Other Services | Public administration | Total intermediate | Private consumption | Government consumption | Fixed capital formation | Export | Import | Total final demand | Total use (domestic production) |
|----------------------|-------------|--------|-----------------------------|--------------------------------|----------------------------------------|---------------------------------------|------------------|-----------------------------|--------------|--------------------------|--------------------------|-----------------------|------------------------|----------------------|----------------|-------------------|------------------|----------------|-----------------------|------------------------|
|                      | 5           | 1      | 11                          | 0                             | 4,238                                  | 797                                   | 0                | 65                          | 443          | -3,684                   | -2,379                   | 3,887                  | 1,017                  | 0                   | 1,618         | 17,719               | -10,749                  | 9,606            | 22,032               |
| Compensation of Employee | 641         | 1,073  | 168                         | 344                           | 12,023                                  | 6,830                                 | 0                | 65                          | 443          | -3,684                   | -2,379                   | 3,887                  | 1,017                  | 0                   | 1,618         | 17,719               | -10,749                  | 9,606            | 22,032               |
| Operating Surplus    | 2,042       | 68     | 696                         | 8                             | 24,975                                  | 802                                   | 8                | 7                          | 66           | -1,449                   | 2,908                    | 7,226                  | 739                    | 0                   | 1,736         | 17,719               | -10,749                  | 9,606            | 22,032               |
| Other value added    | 64          | 7      | 17                          | 8                             | 644                                     | 33                                    | 0                | 65                          | 443          | -3,684                   | -2,379                   | 3,887                  | 1,017                  | 0                   | 1,618         | 17,719               | -10,749                  | 9,606            | 22,032               |
| Total value added    | 2,748       | 1,148  | 882                         | 360                           | 37,641                                  | 1,840                                 | 0                | 65                          | 443          | -3,684                   | -2,379                   | 3,887                  | 1,017                  | 0                   | 1,618         | 17,719               | -10,749                  | 9,606            | 22,032               |
| Total input          | 3,887       | 1,840  | 1,705                       | 793                           | 121,431                                  | 7,053                                 | 0                | 65                          | 443          | -3,684                   | -2,379                   | 3,887                  | 1,017                  | 0                   | 1,618         | 17,719               | -10,749                  | 9,606            | 22,032               |
### Appendix 6: Energy service demand per driving force and fuel share (1/3)

#### 2005

<table>
<thead>
<tr>
<th>Sector</th>
<th>Energy service</th>
<th>Basic unit</th>
<th>Fuel share</th>
<th>Coal</th>
<th>Petroleum</th>
<th>Gas</th>
<th>Renewables</th>
<th>Electricity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td></td>
<td>0.755 toe/household</td>
<td>0%</td>
<td>20%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>Commercial</td>
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<td>55.835 ktoe/mil m²</td>
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<td>14%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>86%</td>
<td>100%</td>
</tr>
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<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
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<td>Mining</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
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<td>31%</td>
<td>43%</td>
<td>0%</td>
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<td>100%</td>
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<tr>
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<td>Chemicals and Chemical Products</td>
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<td>64%</td>
<td>22%</td>
<td>0%</td>
<td>14%</td>
<td>100%</td>
</tr>
<tr>
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<td>Electric and Electronic Products and Machinery</td>
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<td>10%</td>
<td>56%</td>
<td>0%</td>
<td>34%</td>
<td>100%</td>
</tr>
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<td>Fabricated Metal Products and Machinery</td>
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<td>31%</td>
<td>43%</td>
<td>0%</td>
<td>26%</td>
<td>100%</td>
</tr>
<tr>
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<td>Other Non-Metallic</td>
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<td>0%</td>
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<td>56%</td>
<td>28%</td>
<td>0%</td>
<td>17%</td>
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<td>Construction</td>
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<td>46%</td>
<td>34%</td>
<td>0%</td>
<td>20%</td>
<td>100%</td>
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<td>Passenegr railways</td>
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<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
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<td>Bus</td>
<td>0.521 ktoe/mil p-km</td>
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<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
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<td>Motorcar</td>
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<td>99%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
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<tr>
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<td>99%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>Freight transport</td>
<td>Freight railways</td>
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<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Freight vehicle</td>
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<td>99%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
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</table>
Appendix 7: Energy service demand per driving force and fuel share (2/3)

2025BaU (The fuel share is the same as that of the base year.)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Energy service</th>
<th>Basic unit</th>
<th>Coal</th>
<th>Petroleum</th>
<th>Gas</th>
<th>Renewables</th>
<th>Electricity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>Residential</td>
<td>1.597 toe/household</td>
<td>0%</td>
<td>20%</td>
<td>0%</td>
<td>0%</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>Commercial</td>
<td>Commercial</td>
<td>55.835 ktoe/mil m²</td>
<td>0%</td>
<td>14%</td>
<td>0%</td>
<td>0%</td>
<td>86%</td>
<td>100%</td>
</tr>
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## Appendix 8: Energy service demand per driving force and fuel share (3/3)

### 2025CM

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## Appendix 9: Inverse of energy efficiency (1/2)

### 2025BaU (2005=1)

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<td>Other Non-Metallie</td>
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### Appendix 12: List of Set used in C-ExSS calculations

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Appendix 13: List of Parameters and variables used in C-ExSS calculations

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<td>secR</td>
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<tr>
<td>ED_dpg</td>
<td>sec</td>
<td>Performance of dispersed power generation</td>
</tr>
<tr>
<td>EE_dpg</td>
<td>sec</td>
<td>Diffusion of dispersed power generation</td>
</tr>
<tr>
<td>Carbon accumulation</td>
<td>Accumulated CO₂ by trees</td>
<td>tCO₂</td>
</tr>
<tr>
<td>CO₂</td>
<td>sec</td>
<td>Number of trees existing in the area</td>
</tr>
<tr>
<td>CA</td>
<td>-</td>
<td>CO₂ accumulation ability by tree</td>
</tr>
<tr>
<td>Parameter Set</td>
<td>Explanation</td>
<td>Unit</td>
</tr>
<tr>
<td>CO₂</td>
<td>CO2EF</td>
<td>CO₂ emission factor</td>
</tr>
<tr>
<td>CO2</td>
<td>sec,e</td>
<td>CO2 emission</td>
</tr>
<tr>
<td>Cost</td>
<td>Energy service demand of device</td>
<td>ktoe</td>
</tr>
<tr>
<td>DESVD</td>
<td>sec,e,dv</td>
<td>Diffusion rate of device in BaU case</td>
</tr>
<tr>
<td>Dp_BaU</td>
<td>sec,e,dv</td>
<td>Diffusion rate of device in CM case</td>
</tr>
<tr>
<td>UD</td>
<td>sec,e,dv</td>
<td>Unit demand of device</td>
</tr>
<tr>
<td>SQ</td>
<td>sec,e,dv</td>
<td>Supply quantity per unit of device</td>
</tr>
<tr>
<td>CST_add</td>
<td>sec,e</td>
<td>Additional cost</td>
</tr>
<tr>
<td>CSTuni_dev</td>
<td>sec,e,dv</td>
<td>Cost to introduce a unit of device</td>
</tr>
<tr>
<td>LT_dev</td>
<td>sec,e,dv</td>
<td>Life time of device</td>
</tr>
<tr>
<td>CST_dpg</td>
<td>sec</td>
<td>Additional cost to introduce dispersed power generation equipment</td>
</tr>
<tr>
<td>CSTuni_dpg</td>
<td>sec</td>
<td>Cost to introduce dispersed power generation equipment</td>
</tr>
<tr>
<td>LT_dpg</td>
<td>sec,e,dv</td>
<td>Life time of dispersed power generation equipment</td>
</tr>
<tr>
<td>CSTbat</td>
<td>sec</td>
<td>Annual Energy yield per rated system power</td>
</tr>
<tr>
<td>CSTuni_dpg</td>
<td>sec</td>
<td>Cost to introduce dispersed power generation equipment per rated system power</td>
</tr>
<tr>
<td>CSTbat</td>
<td>sec</td>
<td>Additional cost to introduce battery</td>
</tr>
<tr>
<td>Cap</td>
<td>sec</td>
<td>Needed capacity of battery per rated system power of dispersed power generation equipment</td>
</tr>
<tr>
<td>CSTuni_hat</td>
<td>sec</td>
<td>Cost to introduce battery per capacity</td>
</tr>
<tr>
<td>CST_e</td>
<td>e</td>
<td>Life time of battery</td>
</tr>
<tr>
<td>CST_e</td>
<td>e</td>
<td>Reduced energy cost</td>
</tr>
<tr>
<td>CSTuni_e</td>
<td>e</td>
<td>Cost of energy</td>
</tr>
</tbody>
</table>
### Appendix 14: CO₂ emission factor

<table>
<thead>
<tr>
<th>Source</th>
<th>2007</th>
<th>2025BaU</th>
<th>2025CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity [tCO₂/GWh]</td>
<td>560</td>
<td>563</td>
<td>458</td>
</tr>
<tr>
<td>Petroleum [tCO₂/toe]</td>
<td>2.8</td>
<td>2.8</td>
<td>2.8</td>
</tr>
<tr>
<td>LPG [tCO₂/toe]</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Natural gas [tCO₂/toe]</td>
<td>2.1</td>
<td>2.1</td>
<td>2.1</td>
</tr>
</tbody>
</table>

### Appendix 15: List of countermeasures (1/5)

<table>
<thead>
<tr>
<th>No.</th>
<th>Sector</th>
<th>Countermeasure</th>
<th>Action</th>
<th>Performance</th>
<th>Low-carbon countermeasure</th>
<th>Information source of performance</th>
<th>Information source of cost</th>
<th>Diffusion [%]</th>
<th>CO₂ emission reduction [tCO₂]</th>
<th>Contribution in the sector [%]</th>
<th>Contribution in total reduction [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cooling</td>
<td>High efficiency heating pump air conditioner**</td>
<td>3</td>
<td>COP</td>
<td>6.4 (q)</td>
<td>3.01 [unit]</td>
<td>(s) 60%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>District cooling**</td>
<td>3</td>
<td>COP</td>
<td>1.4 (a)</td>
<td>1.02 [unit]</td>
<td>(s) 30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>High efficiency electric boiler**</td>
<td>3</td>
<td>COP</td>
<td>3.0 (b)</td>
<td>3.75 [unit]</td>
<td>(s) 50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hot water**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>High efficiency cooking**</td>
<td>3</td>
<td>Thermal efficiency</td>
<td>0.6 (b)</td>
<td>3.20 [unit]</td>
<td>(s) 40%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>IH cooking heater**</td>
<td>3</td>
<td>Thermal efficiency</td>
<td>0.9 (j)</td>
<td>1.84 [unit]</td>
<td>(s) 30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Lighting</td>
<td>LED (substitute incandescent light)***</td>
<td>3</td>
<td>Energy consumption (conventional type=1)</td>
<td>4.6 (j)</td>
<td>0.11 [unit]</td>
<td>(s) 50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Other electric appliances***</td>
<td>3</td>
<td>Energy consumption (conventional type=1)</td>
<td>1.7 (c)</td>
<td>2.57 [unit]</td>
<td>(s) 50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>BEMS**</td>
<td>3</td>
<td>Energy service demand reduction rate</td>
<td>10% (k)</td>
<td>0.0018 [unit]</td>
<td>(y) 40%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Building insulation</td>
<td>3</td>
<td>Energy service demand reduction rate</td>
<td>50% (j)</td>
<td>0.01 [unit]</td>
<td>(j) 50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Energy saving behavior**</td>
<td>3</td>
<td>Energy service demand reduction rate</td>
<td>10% (m)</td>
<td>-</td>
<td>- 30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>UHI countermeasure</td>
<td>8</td>
<td>Energy service demand reduction rate</td>
<td>11% (d)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Commercial</td>
<td>Photovoltaic power generation at buildings</td>
<td>4</td>
<td>[ktoe/Mill.m²]</td>
<td>8.5 (e)</td>
<td>1.09 [kWp]</td>
<td>(t) 10%</td>
<td>(t) 5,114</td>
<td>1.1%</td>
<td>0.2%</td>
<td></td>
</tr>
</tbody>
</table>

| Subtotal | 451,699 | 100% | 18.8% |
### Appendix 16: List of countermeasures (2/5)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling</td>
<td>High efficiency heat pump air conditioner</td>
<td>(1)</td>
<td>COP 6.44</td>
<td>3.01 [unit] (s)</td>
<td>70%</td>
<td>22,013</td>
<td></td>
<td></td>
<td>23.5%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Hot water</td>
<td>High efficiency electric boiler</td>
<td>(3)</td>
<td>COP 3</td>
<td>3.75 [unit] (s)</td>
<td>50%</td>
<td>9,182</td>
<td></td>
<td></td>
<td>9.8%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Cooking</td>
<td>High efficiency Cooking</td>
<td>(4)</td>
<td>Thermal efficiency</td>
<td>0.56 (b)</td>
<td>3.20 [unit] (s)</td>
<td>40%</td>
<td>954</td>
<td></td>
<td></td>
<td>1.0%</td>
</tr>
<tr>
<td>IH cooking heater</td>
<td>High efficiency IH cooking heater</td>
<td>(5)</td>
<td>Thermal efficiency</td>
<td>0.90 (j)</td>
<td>1.84 [unit] (s)</td>
<td>30%</td>
<td>8,547</td>
<td></td>
<td></td>
<td>9.1%</td>
</tr>
<tr>
<td>Lighting</td>
<td>LED (substitute incandescent light)</td>
<td>(6)</td>
<td>Energy consumption</td>
<td>4.55 (j)</td>
<td>0.11 [unit] (s)</td>
<td>50%</td>
<td>25,492</td>
<td></td>
<td></td>
<td>27.3%</td>
</tr>
<tr>
<td>Other electric appliances***</td>
<td>Energy consumption (conventional type=1)</td>
<td>(7)</td>
<td>Energy consumption</td>
<td>1.67 (c)</td>
<td>2.57 [unit] (s)</td>
<td>60%</td>
<td>24,842</td>
<td></td>
<td></td>
<td>26.6%</td>
</tr>
<tr>
<td>BEMS**</td>
<td>Energy service demand reduction rate</td>
<td>(8)</td>
<td>Energy service demand</td>
<td>10% (k)</td>
<td>0.0018 [unit] (y)</td>
<td>40%</td>
<td>42,558</td>
<td></td>
<td></td>
<td>23.1%</td>
</tr>
<tr>
<td>Building insulation</td>
<td>Energy service demand reduction rate</td>
<td>(9)</td>
<td>Energy service demand</td>
<td>50% (j)</td>
<td>0.0077 [unit] (z)</td>
<td>50%</td>
<td>93,521</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Energy saving behavior**</td>
<td>Energy service demand reduction rate</td>
<td>(10)</td>
<td>Energy service demand</td>
<td>10% (m)</td>
<td>-</td>
<td>30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UHI countermeasure</td>
<td>Energy service demand reduction rate</td>
<td>(11)</td>
<td>Energy service demand</td>
<td>11% (d)</td>
<td>-</td>
<td>30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Photovoltaic power generation at buildings</td>
<td>[ktoe/Mill.m^2]</td>
<td>(12)</td>
<td>8.5 (e) 1.09 [kWp] (t)</td>
<td>10% (u)</td>
<td>2.491</td>
<td>2.7%</td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>93,521</td>
<td></td>
<td></td>
<td>100%</td>
<td>3.9%</td>
</tr>
</tbody>
</table>

**Notes:**
- CO2: Carbon Dioxide
- COP: Coefficient of Performance
- LED: Light Emitting Diode
- BEMS: Building Energy Management System
- UHI: Urban Heat Island
- kWp: Kilowatt peak
- Mill: Million
- [unit]: Unit of measurement

---

Source: [document reference]

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## Appendix 17: List of countermeasures (3/5)

<table>
<thead>
<tr>
<th>No.</th>
<th>Sector</th>
<th>Countermeasure</th>
<th>Performance</th>
<th>Information</th>
<th>Cost [10^3 US$]</th>
<th>Information</th>
<th>Diffusion [%]</th>
<th>Information</th>
<th>CO₂ emission reduction [t CO₂]</th>
<th>Contribution in total reduction [%]</th>
<th>Contribution in the sector [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>(8)</td>
<td>3</td>
<td>BEMS**</td>
<td>Energy service demand reduction rate</td>
<td>0.1 (k) 0.0018 [unit] (y)</td>
<td>60%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9)</td>
<td>3</td>
<td>Building insulation</td>
<td>Energy service demand reduction rate</td>
<td>0.5 (j) 0.008 [unit] (z)</td>
<td>70%</td>
<td>55,941</td>
<td>30.3%</td>
<td>2.3%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10)</td>
<td>3</td>
<td>Energy saving behavior**</td>
<td>Energy service demand reduction rate</td>
<td>0.1 (m) -</td>
<td>- 35%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(11)</td>
<td>8</td>
<td>UHI countermeasure</td>
<td>Energy service demand reduction rate</td>
<td>0.1 (d) -</td>
<td>- 100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(12)</td>
<td>4</td>
<td>Photovoltaic power generation at buildings</td>
<td>[ktoe/Mill.m²]</td>
<td>8.5 (e) 1.09 [kWp] (l) (u)</td>
<td>100%</td>
<td>37,028</td>
<td>20.1%</td>
<td>1.5%</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

### Government departments

Subtotal

<table>
<thead>
<tr>
<th>Subtotal</th>
<th>184,332</th>
<th>100%</th>
<th>7.7%</th>
</tr>
</thead>
</table>

### Residential

| (1) | 3 | High efficiency heat pump air conditioner | COP | 6.44 (q) 1.73 [unit] (s) | 60% |
| (3) | 3 | High efficiency electric boiler | COP | 3.00 (b) 3.75 [unit] (s) | 50% |
| (13) | 3 | Solar water heater | COP | 1.00 4.00 [unit] (s) | 10% |
| (4) | 3 | High efficiency Cooking | COP | 0.56 (b) 3.20 [unit] (s) | 40% |
| (5) | 3 | IH cooking heater | COP | 0.9 (j) 1.84 [unit] (s) | 30% |
| (6) | 3 | LED (substitute incandescent light) | Energy consumption (conventional type=1) | 8.7 (j) 0.11 [unit] (s) | 50% |
| (7) | 3 | Other electric appliances*** | Energy consumption (conventional type=1) | 1.7 (c) 2.37 [unit] (s) | 60% |
| (14) | 3 | HEMS** | Energy service demand reduction rate | 10% (k) 0.09 [unit] (x) | 30% |
| (15-1)| 3 | House insulation (Next generation level) | Energy service demand reduction rate | 64% (l) 0.85 [unit] (z) | 40% |
| (15-2)| 3 | House insulation (New standard) | Energy service demand reduction rate | 57% (l) 0.85 [unit] (z) | 40% |
| (10) | 3 | Energy saving behavior** | Energy service demand reduction rate | 10% (m) 0 | - 30%         |
| (16) | 8 | UHI countermeasure | Energy service demand reduction rate | 11% (d) 0 |              |
| (12) | 4 | Photovoltaic power generation at buildings | [ktoe/Mill.m²] | 8.5 (e) 1.09 [kWp] (l) (u) | 6% |

Subtotal

| Subtotal | 77,305 | 100% | 3.2% |

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### Appendix 18: List of countermeasures (4/5)

<table>
<thead>
<tr>
<th>No.</th>
<th>Sector</th>
<th>Countermeasure</th>
<th>Performance</th>
<th>Cost [1000 US$]</th>
<th>Contribution in CO₂ emissions reduction [%]</th>
<th>Contribution in the total reduction [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Efficiency improvement of motorcycles, automobiles, buses</td>
<td>Energy efficiency [Mill.pass-km/ktoe]</td>
<td>386,031</td>
<td>41.1</td>
<td>16.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High efficiency motorcycle</td>
<td>Energy efficiency [Mill.pass-km/ktoe]</td>
<td>17</td>
<td>(g)</td>
<td>0.56 [unit]</td>
</tr>
<tr>
<td>(16) 2</td>
<td>Passenger transport</td>
<td>High efficiency internal combustion vehicle</td>
<td>Energy efficiency [Mill.pass-km/ktoe]</td>
<td>12</td>
<td>(h)</td>
<td>2.20 [unit]</td>
</tr>
<tr>
<td>(17) 2</td>
<td></td>
<td>Hybrid vehicle</td>
<td>Energy efficiency [Mill.pass-km/ktoe]</td>
<td>12</td>
<td>(b)</td>
<td>2.28 [unit]</td>
</tr>
<tr>
<td>(18) 2</td>
<td></td>
<td>Electric vehicle</td>
<td>Energy efficiency [Mill.pass-km/ktoe]</td>
<td>29</td>
<td>(b)</td>
<td>3.31 [unit]</td>
</tr>
<tr>
<td>(19) 2</td>
<td></td>
<td>High efficiency natural gas vehicle</td>
<td>Energy efficiency [Mill.pass-km/ktoe]</td>
<td>20</td>
<td>(f)</td>
<td>2.21 [unit]</td>
</tr>
<tr>
<td>(20) 2</td>
<td></td>
<td>High efficiency natural gas bus</td>
<td>Energy efficiency [Mill.pass-km/ktoe]</td>
<td>216</td>
<td>(f)</td>
<td>15.04 [unit]</td>
</tr>
<tr>
<td>(21) 2</td>
<td></td>
<td>Efficiency improvement of trains</td>
<td>Energy efficiency [Mill.pass-km/ktoe]</td>
<td>532</td>
<td>(h)</td>
<td>10.00 [unit]</td>
</tr>
<tr>
<td>(22) 2</td>
<td></td>
<td>Modal shift</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(23) 2</td>
<td></td>
<td>Pedestrian-friendly city development (Mo)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(24) 1</td>
<td></td>
<td>Introduction of new rail line (o)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(25) 2</td>
<td></td>
<td>Shorter trip distance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(26) 2</td>
<td></td>
<td>Mixed use development (Shorter trip distance)</td>
<td>Energy service demand reduction rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(27) 1</td>
<td></td>
<td>ITS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(28) 2</td>
<td></td>
<td>High efficiency freight vehicle</td>
<td>Energy efficiency [Mill.t-km/ktoe]</td>
<td>40,258</td>
<td>60.2%</td>
<td>1.7%</td>
</tr>
<tr>
<td>(29) -</td>
<td>Freight transport</td>
<td>High efficiency freight vehicle</td>
<td>Energy efficiency [Mill.t-km/ktoe]</td>
<td>21</td>
<td>(j)</td>
<td>12.73 [unit]</td>
</tr>
<tr>
<td>(30) -</td>
<td></td>
<td>High efficiency bio-diesel freight vehicle</td>
<td>Energy efficiency [Mill.t-km/ktoe]</td>
<td>26</td>
<td>(r)</td>
<td>12.73 [unit]</td>
</tr>
<tr>
<td>-</td>
<td></td>
<td>Efficiency improvement of logistics</td>
<td>Energy service demand reduction rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(28) 2</td>
<td></td>
<td>ITS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Total

Subtotal: 393,095 100% 39.0%

Subtotal: 66,915 100% 2.8%
### Appendix 19: List of countermeasures (5/5)

<table>
<thead>
<tr>
<th>No.</th>
<th>Sector</th>
<th>Countermeasure</th>
<th>Performance</th>
<th>CO₂ emission factor [tCO₂/kt]</th>
<th>Information source of performance</th>
<th>Cost [1,000 US$]</th>
<th>Information source of cost</th>
<th>CO₂ emission reduction [%]</th>
<th>Contribution in the sector [%]</th>
<th>Contribution in total reduction [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>(32)</td>
<td>-</td>
<td>Central power generation</td>
<td>5,323 (n)</td>
<td>332,640</td>
<td>13.8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(33)</td>
<td>6</td>
<td>Carbon sink (Tree planting)</td>
<td>(i)</td>
<td>35,420</td>
<td>1.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(34)</td>
<td>9&amp; 11</td>
<td>Solid waste management*****</td>
<td></td>
<td>224,150</td>
<td>9.3%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>2,405,077</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* "Diffusion" means the rate of distribution in services (e.g. "Cooling", "Motorcycle, Automobile, Bus" etc.) or the percentage of units introduced in a specific countermeasure (HEMS/BEMS, Energy saving behavior etc.)

The list is only of energy efficient technology, so conventional technology is not listed here.

** The difference between "HEMS/BEMS" and "Energy saving behavior" is that the former is contribution of introducing HEMS/BEMS device, and the latter is action such as switching off the light when leave the room.

*** Other electric appliances includes Vending machine, Elevator, Printer, TV, Refrigerator etc.

**** They are not included in CO₂ reductions by Actions.

***** Its CO₂ emission reduction includes other GHG converted in tCO₂.

It is excluded from targeted CO₂ emission reduction in "Low-carbon Putrajaya" (60% reduction).

**Information sources**


(b) Research project to Establish a Methodology to Evaluate Mid to Long Term Environmental Policy Options towards Asian Low-Carbon Societies (2007): Environmental Options’ Database (EDB) working paper.


(g) Honda Motor Co., Ltd. (Website): http://www.honda.co.jp/environment/activities/product/motorcycle/da020200.html

(h) AIM project team, National Institute for Environmental Studies, Japan (2010): Applying the AIM/Enduse Model to Japan, Ver.1.


(j) Mizuho Information & Research Institute, Inc. (2005): Report on investigation for scenario making and simulation program "Chapter 4 Scenario of measures"

(k) Ministry of Economy, Trade and Industry, Japan (2005): Strategic technology roadmap in energy field -Energy Technology Vision 2100-


(m) Roadmap committee, Shiga Prefecture Sustainable Society Research Team, Japan (2006)

(n) Clean Coal Power R&D Co., Ltd.: http://www.ccpower.co.jp/

(o) The effect was assumed in this study.

(p) Ministry of Land, Infrastructure, Transport and Tourism, Japan (Website): http://www.mlit.go.jp/

(q) The Energy Conservation Center, Japan (2007): Catalog of energy-saving performance 2007 winter


(v) NEDO, Battery technology development section, fuel cell & hydro technology development division (2005):
Battery RM2010


(x) NEC corporation (Website): http://www.nec.co.jp/press/ja/1010/0801.html


(aa) Honda Motor Co., Ltd. (Website): http://www.honda.co.jp/FAZE/


### Appendix 20: List of Sub-actions & Programs in Action 1

<table>
<thead>
<tr>
<th>Sub-action</th>
<th>Programs</th>
</tr>
</thead>
</table>
| **Make cycling as preferred transport option (Bikeable City)**            | 1) Separate route for cyclist and pedestrian  
2) Facilities for bicycle (bicycle parking spaces)  
3) Facilities for cyclist (shower facilities etc.)  
4) bicycle, tricycle rental/shared bicycle, tricycle program  
5) Celebrity cyclist encouragement program  
6) Provide more shade through landscape  
7) Bicycle repair shop  
8) Incentive for setting up bicycle & repair shop  
9) Planning & Design Action Plan for Cyclist  
10) Priority lighting for cyclist  
11) Improvement on the existing cyclist lane  
12) Safer School Route                                                                 |
| **Make walking as preferred transport option (Walkable City)**            | 1) Separate route for cyclist and pedestrian  
2) Covered pedestrian walkways  
3) Pedestrian Streets  
4) Apply Universal Design Concept (Disable, Senior Citizen, Children etc.)  
5) Safer School Route  
6) Crime Prevention Through Environmental Design (CPTED)  
7) Planning & Design Action Plan for Pedestrian  
8) Pedestrian R & R  
   - Drinking water  
   - Benches  
   - Information kiosk  
   - Police beat  |
| **Enhance mixed-use and diversified development**                        | 1) Encourage Putrajaya Holdings Sdn Bhd (PHSB) to expedite the development of existing mixed-use plots  
2) Mixed activities within the same building (flexible usage)                                                                 |
| **Residential Layout Planning**                                           | 1) Orientation/ Alignment of the House/Building  
2) Introduce residential element within other development plots (SOHO)                                                                 |
| **Introduce Low Carbon Planning Control & Development Plans & Practices**| 1) Encourage Putrajaya Holdings Sdn Bhd (PHSB) to expedite the development of existing mixed-use plots  
2) Mixed activities within the same building (flexible usage)                                                                 |
| **Allocate Land for Solid Waste Management Facilities Management Plan**  | 1) Orientation/ Alignment of the House/Building  
2) Introduce residential element within other development plots (SOHO)                                                                 |
<table>
<thead>
<tr>
<th>Sub-action</th>
<th>Programs</th>
</tr>
</thead>
</table>
| **2-1 Encourage the Use of Low-carbon emission vehicles** | 1) Encourage walking/cycling to school  
2) Total ban of diesel engine buses from entering Putrajaya (buses can be parked at Park And Ride)  
3) Expend Nadiputra’s services to the surrounding areas (within 25km radius)  
4) Government to promote hybrid/electric vehicle  
5) Government to assist petrol station operators to provide infrastructure needed.  
6) Government agencies to use hybrid/electric vehicle.  
7) Incentives (rebate, tax reduction, etc) for the usage of hybrid/electric vehicle for Putrajaya resident.  
8) Government to expedite to regulate Euro 4M fuel and to assist petrol station operators to provide infrastructure needed for Euro 4M fuel.  
9) Incentives (rebate, tax reduction, etc) for the usage of Euro 4M vehicle for Putrajaya government and resident. |
| **2-2 Implement Integrated Transportation System** | 1) Government to implement Bus Rapid Transit (BRT)/Dedicated Transport System (DTS) to Putrajaya.  
2) To implement rail system inbound Putrajaya residential area and government complex.  
3) The Putrajaya rail system is to be connected to central rail system (MRT & LRT).  
4) To study the feasibility of using water taxi (battery/electric operated).  
5) Implementation bicycle/tricycle for rent. |
| **2-3 Implement Intelligent Transportation System** | 1) To enhance the existing traffic light system.  
2) To enhance the existing variable message sign (VMS).  
3) To implement congestion/cordon charging  
4) To enhance the existing Advanced Public Transportation System (APTS).  
5) To implement bus junction priority  
6) To regularly introduce new transport management technology/system. |
| **2-4 Encourage Transit Oriented Development (TOD)** | 1) Identify high density nodes for station development.  
2) Review land use density along rail base transport route  
3) Parking management at transit station  
4) Integration of all modes of transportation to transit station  
5) Mixed used and high density development at transit station |
| **2-5 Increase Public Transport Provision & Usage** | 1) Limit parking spaces for private vehicle  
2) Impose Traffic Restraint into Core Island  
3) Improve Bus Routing to reduce travel time  
4) Increase bus trip frequency  
5) Introduce water taxi (solar power/battery)  
6) Introduce rail base transport in Putrajaya  
7) Rail base connectivity between KL - Putrajaya (Greater KL)  
8) Real time schedule information |
## Appendix 22: List of Sub-actions & Programs in Action 3

<table>
<thead>
<tr>
<th>Sub-action</th>
<th>Programs</th>
</tr>
</thead>
</table>
| **3-1 Eco friendly Building Materials & Energy Efficient Labeling for Equipments & Appliances.** | 1) Promotion of Building Materials which are recyclable or Low Carbon Materials.  
2) To use high Energy Efficiency appliances in Buildings.  
3) Water saving equipments in Toilets (e.g. faucets, flushing etc.)  
|  | 1) To introduce BEMS in all Government Buildings.  
2) Improvement of the Building Automated system.  
- Review the Default temperature of Air conditioner to be higher.  
- During off peak hours and weekend to minimize the number of Elevators used.  
- To have sensors for Lightings in Buildings (e.g. Low occupancy areas- stairwells, toilets, walkways)  
- To review Existing Regulations/law with Regards to Electricity supply and GDC.  |
| **Building Energy Management System (BEMS)** | 3-2 To look not only at the design of the building, but also the interior design and maintenance of the building.  |
| **3-3 Eco friendly Building Materials** | 3-4 Have proper recycling facilities in Buildings to replace the current waste bins in buildings. (For standardization in all buildings, and for ecstatic and cleanliness of building surroundings)  |
| **3-4 To integrate Recycling facilities in building designs.** | 3) PJC will decide on the Rating Tool- Green Building Index or equivalent to achieve all buildings certified green by 2025.  
a. Existing buildings (Public)  
- Audit status of all buildings.  
- Retrofit these buildings within the next 15 years to achieve certified rating. By 10th year - 75% of all existing buildings.  
b. Under construction  
- To upgrade within 5 years after completion to fulfill minimum certified rating. - Mostly upgrading of active elements only.  
c. New buildings  
- All new buildings must have minimum certified rating.  
d. Private commercial buildings  
- Same as public buildings.  
- Local authority to come out with incentives. (e.g. Reduction in development charges, fast green lane approval, etc.)  
- Buildings to be have a Minimum Rating Type: GBI certified or equivalent.  |
| **3-5 Impose Building Rating System to all Buildings** |  |
Appendix 23: List of Sub-actions & Programs in Action 4

<table>
<thead>
<tr>
<th>Sub-action</th>
<th>Programs</th>
</tr>
</thead>
</table>
| 4-1 Energy Efficient Appliances in Homes. | 1) Promotion to create awareness.  
2) High rise residential areas (Apartments/condos)  
   - The common spaces to be retrofit with energy management system.  
   - Existing buildings are to be retrofit within the next 5 years. |
| 4-2 HEMS (Home Energy Management System)* | 1) House automated system- (for lighting, security and etc.) |
| 4-3 Promoting organic / low carbon products | 1) Provide more outlets to sell organic / low carbon products.  
2) Incentives : introducing eco points and similar other incentives  
3) To encourage and intensify the ‘Bumi Hijau’ initiative.(Organic Food and Low Carbon because food is not imported from out of Putrajaya) |
| 4-4 To integrate Recycling facilities in High rise residential building designs. | 1) Have proper recycling facilities in High rise Residential Buildings (Especially Government Quarters)  
2) This will be imposed as a regulation in all government quarters. (For standardization in all buildings, and for ecstatic and cleanliness of building surroundings) |

Appendix 24: List of Sub-actions & Programs in Action 5 (1/2)

<table>
<thead>
<tr>
<th>Sub-action</th>
<th>Programs</th>
</tr>
</thead>
</table>
| 5-1 Photovoltaic power generation and utilization | 1) To implement 5 megawatt project solar farm (TNB)  
2) To study the feasibility of using PV/(+hybrid) power generation on these buildings/facilities  
   - Administrative and Commercial Building Lighting with efficient lamp  
   - Residential area  
   - Bus stop  
   - Traffic light  
   - Advertisement/road signage  
   - Street lighting  
   - Irrigation solar pump  
   - Charging station electric vehicles  
   - Solar A/C unit  
3) To implement measure identified if feasible  
4) To review existing regulation/law and agreement with regard to electricity supply |
| 5-2 Alternative fuel source from Solar assisted power generation | 1) To study feasibility of using Hydrogen production for fuel cell for public transportation  
   - To implement measure identified if feasible  
   - To review existing regulation/law |
| 5-3 Explore possibilities of utilizing Solar Thermal | 1) To study the feasibility of using solar thermal for the following application  
   - hot water for domestic use, hospital and hotel  
   - Concentrated Solar Power (CSP)  
   - Solar desiccant |
| 5-4 Biomass production & utilization | 1) To study the feasibility of anaerobic digestion of municipal waste, sewerage waste for methane production  
2) To study the feasibility of anaerobic digestion of direct combustion using incinerator or plasma for heat production  
   - The water temperature difference between the water on the surface and bottom of lake. (e.g. pump water from Bottom of lake will be (Cooler water) to chill in GDC) |
### Appendix 25: List of Sub-actions & Programs in Action 5 (2/2)

<table>
<thead>
<tr>
<th>Sub-action</th>
<th>Programs</th>
</tr>
</thead>
</table>
| 1) | To study the feasibility of using water from lake for thermal sink (lower temperature of the lake bed water) for GDC operation (Present 5)  
- The water temperature difference between the water on the surface and bottom of lake. (e.g. - pump water from bottom of lake will be (Cooler water) to chill in GDC) |
| 2) | To explore opportunities for Co-generation from existing GDC plants.  
- To review existing regulation/law  
- To implement the use of waste heat from GDC to generate  
  > Electric  
  > Heat  
  > Cooling (absorption chiller) |
| 3) | To explore the feasibility of using small wind turbine system (+hybrid) with low speed for electricity generation |

### Appendix 26: List of Sub-actions & Programs in Action 6

<table>
<thead>
<tr>
<th>Sub-action</th>
<th>Programs</th>
</tr>
</thead>
</table>
| 1) | Suitable species for planting at different locations:  
- Along roadsides  
- Monorail reserves  
- Buffer zones  
- Around lake area for filtration  
- Tree planting program integrates with rain water harvesting |
| 2) | To increase Urban Forest Areas by:  
- Naturalize planting; instead of plantation  
- Native/indigenous species  
- Wider planting strips |
| 3) | Urban Forest  
- Plant selection contributing to carbon sink - saff flower  
- Urban Forest Management Plan |
| 4) | Wetlands-plant selection contributing to carbon sink |
| 5) | Lake - Water harvesting for irrigation |
| 6) | Parks & Open Spaces - introduce plant with highest carbon sink (bamboo) |
| 7) | To regulate the use of GDC in all commercial buildings within the CBD. Gas District Cooling (GDC) |
| 8) | Rainwater Harvesting |
| 9) | To collect these data:  
- No of Trees Planted  
- Species of Trees Planted  
- Diameter of Trees  
- Growth Speed |
| 10) | To derive the Carbon Accounting from the Inventory data. |
| 11) | Create wild life crossings and animal bridges |
| 12) | Enhance ecology |
| 13) | Explore possibilities of using green areas, lake and wetland as carbon sink. |
| 14) | Extensively promote roof top and vertical gardens |
| 15) | Conduct Research & Development activities on tree selection, maintenance, carbon sequestration, carrying capacity, etc. |
| 16) | Composting of tree waste below ground as Carbon Storage. |
## Appendix 27: List of Participants (1/2)

<table>
<thead>
<tr>
<th>Bil.</th>
<th>Name and agency</th>
<th>No of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Perbadanan Putrajaya</td>
<td>38</td>
</tr>
<tr>
<td>2.</td>
<td>Kementerian Tenaga, Teknologi Hijau dan Air (KeTTHA)</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>Kementerian Sumber Asli dan Alam Sekitar (NRE)</td>
<td>3</td>
</tr>
<tr>
<td>4.</td>
<td>Kementerian Wilayah Persekutuan &amp; Kesejahteraan Bandar</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>• Bahagian Perkhidmatan Teknikal &amp; Geospatial</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Jabatan Perancangan Bandar &amp; Desa Semenanjung Malaysia</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>• Bahagian Penyelidikan &amp; Pembangunan</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Majlis Perbandaran Sepang</td>
<td>2</td>
</tr>
<tr>
<td>7.</td>
<td>Malaysia Green Technology Corporation</td>
<td>2</td>
</tr>
<tr>
<td>8.</td>
<td>Jabatan Perdana Menteri (Bahagian Pengurusan Hartanah)</td>
<td>2</td>
</tr>
<tr>
<td>9.</td>
<td>Jabatan Kerja Raya Putrajaya</td>
<td>3</td>
</tr>
<tr>
<td>10.</td>
<td>Putrajaya Holdings Sdn Bhd</td>
<td>3</td>
</tr>
<tr>
<td>11.</td>
<td>Sime Darby Berhad</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>• Energy Utilities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Property</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Setia Putrajaya Development Sdn. Bhd.</td>
<td>1</td>
</tr>
<tr>
<td>13.</td>
<td>Senandung Budiman Sdn. Bhd.</td>
<td>1</td>
</tr>
<tr>
<td>15.</td>
<td>Tenaga Nasional Berhad</td>
<td>1</td>
</tr>
<tr>
<td>16.</td>
<td>Stesen Janaelektrik Putrajaya</td>
<td>1</td>
</tr>
</tbody>
</table>
### Appendix 28: List of Participants (2/2)

<table>
<thead>
<tr>
<th>Bil.</th>
<th>Name and agency</th>
<th>No of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.</td>
<td>GAS Malaysia</td>
<td>1</td>
</tr>
<tr>
<td>18.</td>
<td>Gas District Cooling</td>
<td>1</td>
</tr>
<tr>
<td>19.</td>
<td>Higher Institutions and Research Institutes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. Universiti Kebangsaan Malaysia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Solar Energy Research Institute (SERI)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>• Institut Alam Sekitar dan Pembangunan (LESTARI)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii. Universiti Putra Malaysia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii. University Teknologi Mara (UiTM)</td>
<td></td>
</tr>
<tr>
<td>20.</td>
<td>Non Government Organization (NGO)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Centre for Environment, Technology &amp; Development, Malaysia (CETDEM) <em>(climate change / sustainable energy / organic farming)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Centre For Environmental Technologies (CETEC) <em>(Environmental Technology)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Environmental Management and Research Association of Malaysia (ENSEARCH) <em>(solid waste management)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Environmental Protection Society Malaysia (EPSM) <em>(prevent environmental deterioration)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Global Environment Centre (GEC) <em>(partnership with department of Drainage Irrigation Penang)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Malaysian Nature Society (MNS) <em>(to promote the study, appreciation, conservation and protection of Malaysia’s natural heritage)</em></td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>• Sustainable Development Network Malaysia (SUSDEN) <em>(Protect and conserve Malaysia as part of that life sustaining organism)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Treat Every Environment Special Sdn. Bhd. (TrEES) <em>(Conservation and management of Malaysia’s natural resources)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Wetlands International (Malaysia) <em>(Mainstreaming the role of wetlands in sustainable development)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• World Wide Fund For Nature (WWF) Malaysia <em>(environmental protection and nature conservation work in Malaysia)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Water Watch Penang (WWP) <em>(Water conservations)</em></td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td>Other Agencies and Representatives from the Public.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The Malaysian Institute of Planners (MIP)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Pertubuhan Akitek Malaysia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The Association Of Consulting Engineer Malaysia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Multimedia Development Corporation Sdn. Bhd. (MDeC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Yayasan Anak Warisan Alam (YAWA)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Persatuan Penduduk Presint 8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Persatuan Penduduk Presint 14</td>
<td>7</td>
</tr>
</tbody>
</table>
24-degrees Celsius ruling in government offices being formalized

KUALA LUMPUR: The Energy, Green Technology and Water Ministry is preparing a letter of instruction to set up a minimum air-conditioning temperature of 24-degrees Celsius at all government offices, Parliament was told Thursday.

Deputy Minister Noriah Kasnon said the new regulation was for office spaces, officers' rooms, meeting rooms, lobby and corridors.

She said critical places like operation theatres, intensive care units, mechanical equipment rooms and server rooms where low temperatures were necessary were exempted from the ruling.

"All government agencies must observe the directive as outlined in the letter of instruction to help reduce the government's utility costs," she said when replying to a question by Dr Mujahid Yusof Rawa (PAS-Parit Buntar).

Noriah said the energy-saving step must be implemented immediately, adding that all parties should play their role to achieve the energy efficiency targets.

"All parties and individuals also need to practise energy efficiency steps, such as switching off all electrical appliances when they are not in use, maximising the use of natural light, taking the stairs and using energy-efficient equipments.

"The practice does not involve any cost to the owner of the building, but usually can save energy up to 7% of the total energy consumption," she added. - Bernama
All government offices to keep air-conditioning temperature at 24°C from now
By ZUHRIN AZAM AHMAD
zuhrimazam@thestar.com.my
Friday August 12, 2011

PUTRAJAYA: All government offices have been ordered to set their air-conditioner temperature no lower than 24 degrees Celsius to give nature a helping hand and to cut electricity bills.

The new regulation is expected to be implemented immediately although the circular on the matter will only be issued by the office of the Chief Secretary to the Government later this month.

Energy, Green Technology and Water Chin said the order would be extended to the private sector by 2013.

He said a new Bill on energy conservation was being drafted to compel the private sector to follow suit.

“It will be tabled in Parliament soon and we are looking at 2013 as the implementation date for the private sector.

“For now, the secretaries-general of all the ministries who are also the officers-in-charge of the buildings under their ministries must ensure that the air-conditioner temperature is set at 24 degrees Celsius and above unless under special circumstances,” he told a press conference after attending a Green Technology and Climate Change Council meeting chaired by Prime Minister Datuk Seri Najib Tun Razak.

It was also attended by Natural Resources and Environment Minister Datuk Douglas Uggah Embas.

Chin said certain places like the ICUs and operation theatres in hospitals were, however, exempted from the ruling.

He said the meeting agreed that 24 degrees Celsius was a comfortable temperature for Malaysian climate.
“It is neither too cold nor too hot. In some countries, like China, they are required to set their (air-conditioner) temperatures at 26 degrees Celsius which is too hot (for Malaysia).

“So gone are the days when the ladies have to bring their shawls to the office,” he said, referring to the common scene in many government offices where women staff covered their upper bodies with shawls due to the cold temperature.

Chin explained that for every degree dropped in air-conditioning temperature, the power usage would increase by between 4% and 7%.

He was unable to provide exact estimates on how much the Government could save with the move.

However, he said the ministry's Malaysia Green Technology Corporation building in Bangi which had already imposed the condition saved an estimated RM600,000 to RM700,000 annually on its energy bills.

“Offices in Putrajaya spend between RM30,000 and RM80,000 a month on electricity and about 40% of it is for air-conditioning,” he said.

He added that the meeting also agreed that all bulbs in government buildings that need to be changed must be replaced with energy-efficient CFL bulbs or LEDs.

On Malaysia's commitment to reduce carbon emission intensity by 40% in 2020, Chin said the country has passed the halfway mark.

“To date, we have reduced intensity by 29.7 million metric tons and to meet the 40% target, we need to reduce it by 40 million metric tons,” he said.
Policy over temperature limit gets warm reception
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PETALING JAYA: The latest policy to set a temperature limit on air-conditioners in government offices has received the thumbs up from various organisations.

Consumers Association of Penang president S.M. Mohamed Idris lauded the move but called for the policy to be implemented in the private sector immediately instead of in 2013.

“There is no need to wait. The policy should be extended to industries and the commercial sector while individuals should also practise energy-saving steps on their own accord,” he said.

He added that the people should also learn to switch off electrical appliances such as televisions and lights when they were not needed to avoid depleting the country's energy resources.

Water & Energy Consumers Association Malaysia secretary-general Soon Weng Lian said the move was timely as there was a need to reduce energy consumption.

Soon said the construction of future buildings must also take into consideration the need for natural ventilation and shade if the energy-saving move was to be further extended.

Malaysian Employers Federation executive director Shamsuddin Bardansaid the Government had to be mindful that there were certain operations, such as a company's server room, that required the room temperature to be lower than 24C.

He hoped the Government would study the policy carefully before implementing it to ensure companies were not penalised unnecessarily.

FOMCA president Datuk N. Marimuthu said individual consumers could also play a role by switching off electrical appliances when not in use instead of putting the items on stand-by mode.
Appendix 32: Formulation of C-ExSS

This chapter shows formulas for future estimation in C-ExSS. Overlined factors (\textit{factor}) are exogenous variables or parameters, so users need to input those data.

**Base year**

**Demography and Economy**

(1) Sales

\[
\text{Sal}_{com} = \sum_{secR, goods} (\text{Exp}_{hhd} \times \text{HHD}_{secR}) \times 10^6 \times (\text{LN}_{com} / \sum_{com} \text{LN}_{com})
\]

Where,

- \text{Sal}_{com}: Sales of sector \textit{com} [monetary]
- \text{Exp}_{hhd}: Expenditure per household of sector \textit{secR} [Mill.monetary]
- \text{HHD}_{secR}: Household number of sector \textit{secR} [no.]
- \text{LN}_{com}: The number of employment [person]
- \textit{Com}: Commercial sector
- \textit{secR}: Residential sector
- \textit{goods}: Goods for household

(2) Sales share

\[
\text{Sal}_{-S_{com}} = \text{Sal}_{com} \times \sum_{com} \text{Sal}_{com}
\]

Where,

- \text{Sal}_{-S_{com}}: Sales share of sector \textit{com} in total sales [-]

**Passenger transport**

(1) Passenger transport demand

\[
P_{TD_{pm}} = (\sum_{secR, NR} \text{INprs}_{secR, NR} + \sum_{secR} \text{Pop}_{secR}) \times PTG \times PT_{S_{pm}} \times PT_{AD_{pm}} \times 365 / 10^6
\]

Where,

- \text{PTD}_{pm}: Passenger transport demand by passenger transport mode \textit{pm} [Mill.pass-km]
- \text{INprs}_{secR, NR}: In-coming persons to sector \textit{secNR} [person]
- \text{Pop}_{secR}: Population in sector \textit{secR} [person]
- \text{PTG}: Passenger trip generation per person per day [trip/person/day]
- \text{PT}_{S_{pm}}: Modal share of passenger transport mode \textit{pm} [-]
\[ PTAD_{ptm} : \text{Average trip distance of passenger transport mode } ptm \ [\text{km/trip}] \]

\[ sec : \text{Sector} \]

\[ ptm : \text{Passenger transport mode} \]

**Freight transport demand**

\[ FTD_{fm} \ (\text{Freight transport demand by freight transport mode } fm \ [\text{t-km}]) \text{ is exogenous variable.} \]

**Energy demand**

(1) **Driving force of energy demand sectors**

\[ ESDF_{sec} \ (\text{The amount of activities by sector } sec \ [\text{person}] \text{ or } [\text{m}^2]) \text{ is set as shown below} \]

\[
\begin{array}{ccc}
\text{Sector} & \text{Service} & \text{ESDF} \\
\text{SecNR} \ esc & FA_{sec.NR} & \\
\text{SecR} \ esc1 & FA_{sec.R} & \\
& esc2 & Pop_{sec.R} \\
\text{PT} \ ptm & PTD_{ptm} & \\
\text{FT} \ ftm & FTD_{fm} & \\
\end{array}
\]

Where,

\[ FA_{sec} : \text{Floor area of sector of sector } sec \ [\text{m}^2] \]

\[ Pop_{secR} : \text{Population of sector } secR \ [\text{person}] \]

\[ PTD_{ptm} : \text{Passenger transport demand by passenger transport mode } ptm \ [\text{Mill.pass-km}] \]

\[ FTD_{fm} : \text{Freight transport demand by freight transport mode } fm \ [\text{t-km}] \]

(2) **Energy service generation**

\[
ESVG_{sec,esc} = \frac{ESDF_{sec}}{ESVD_{sec,esc}} \]

Where,

\[ ESVD_{sec,esc} : \text{Energy service demand of service } esc \text{ by sector } sec \ [\text{ktoe}] \]

\[ ESDF_{sec} : \text{The amount of activities by sector } sec \ [\text{person}] \text{ or } [\text{m}^2] \]

\[ ESVG_{sec,esc} : \text{Energy service generation by service } esc \ [\text{ktoe/person} \text{ or } \text{ktoe/m}^2] \ (ESVG \text{ is defined to be “1” for sector } PT \text{ and } FT) \]

(3) **Energy service demand**

\[
ESVD_{e,sec,esc} = \frac{ED_{sec,esc,e}}{EE_{sec,esc,e}} \]
Where,

\[ ESVD_{sec,esc,e} : \text{Energy service demand by fuel } e, \text{ of service } esc, \text{ by sector } sec \text{ [ktoe]} \]

\[ ED_{sec,esc,e} : \text{Energy demand of service } esc, \text{ fuel } e \text{ by sector } sec \text{ [ktoe]} \]

\[ EE_{sec,esc,e} : \text{Energy efficiency of fuel } e, \text{ service } esc, \text{ sector } sec \text{ [-]} \]

\[ ESVD_{sec,esc} : \text{Energy service demand of service } esc \text{ by sector } sec \text{ [ktoe]} \]

\( sec \): Sector

\( esc \): Service

\( e \): Fuel

(4) Fuel share

\[ FS_{sec,esc,e} = ESVD_{e,sec,esc,e} / \sum_{e} ESVD_{e,sec,esc,e} \]  

Where,

\[ FS_{sec,esc,e} : \text{Fuel share of fuel } e, \text{ service } esc \text{ by sector } sec \text{ [-]} \]

\[ ESVD_{e,sec,esc,e} : \text{Energy service demand by fuel } e, \text{ of service } esc, \text{ by sector } sec \text{ [ktoe]} \]

\( sec \): Sector

\( esc \): Service

\( e \): Fuel

\[ CO2_{sec,e} = \left( \sum_{esc} ED_{esc,sec,e} \right) - ED_{sec} - dp_{sec} \times CO2EF_e \]  

Where,

\[ CO2_{sec,e} : \text{CO}_2 \text{ emission [tCO}_2\text{]} \]

\[ ED_{sec,esc,e} : \text{Energy demand of service } esc, \text{ fuel } e \text{ by sector } sec \text{ [ktoe]} \]
Energy demand for electricity generated by dispersed power generation [ktoe]

$\text{CO}_2\text{E}_F$ : CO$_2$ emission factor of fuel [tCO$_2$/ktoe]

**Target year**

**Demography and Economy**

(1) Household number

$$HHD_{secR} = \frac{Pop_{secR}}{Pphhd_{secR}}$$  \hspace{1cm} (9)

*Where,*

- $HHD_{secR}$ : Household number of sector $secR$ [no.]
- $Pop_{secR}$ : Population [no.]
- $Pphhd_{secR}$ : Household size of sector $secR$ [person/household]
- $secR$ : Residential sector

(2) Sales

$$Sal_{com} = \sum_{secR,goods} (\text{Exp}_{hhd_{secR,goods}} \times HHD_{secR}) \times 10^4 \times Sal_{S_{com}}$$  \hspace{1cm} (10)

*Where F,*

- $Sal_{com}$ : Sales of sector $com$ [monetary/year]
- $\text{Exp}_{hhd_{secR,goods}}$ : Expenditure on goods, per household of sector $secR$ [Mill. Monetary/year]

$HHD_{secR}$ : Household number of sector $secR$ [no.]

$Sal_{S_{com}}$ : Sales share of sector $com$ in total sales [-]

$secR$ : Residential sector

*goods*: Goods for household

**Passenger transport**

(1) **Passenger transport demand**

Formulation for Passenger transport demand in target year is same with base year.

(See also 0(1))

**Freight transport demand**

Same with base year, Freight transport demand by freight transport mode $ftm$ in target year is exogenous variable.
Energy demand

(1) Driving force of energy demand sectors
Driving force of energy demand sectors are same with base year. (See also 0(1).)

(2) Energy service demand
\[ ESVD_{sec,esc} = \frac{ESDF_{sec} \times ESVG_{sec,esc}}{} \] (11)
Where,
- \( ESVD_{sec,esc} \): Energy service demand of service \( esc \) by sector \( sec \) [ktoe]
- \( ESDF_{sec} \): The amount of activities by sector \( sec \) [person] or \([\text{m}^2]\)
- \( ESVG_{sec,esc} \): Energy service generation by service \( esc \) [ktoe/person] or[ktoe/\( \text{m}^2 \)] (ESVG is defined to be “1” for sector PT and FT)

(3) Energy service demand by fuel
\[ ESVD_{e,sec,esc} = ESVD_{sec,esc} \times FS_{sec,esc,e} \] (12)
Where,
- \( ESVD_{e,sec,esc} \): Energy service demand by fuel \( e \), of service \( esc \), by sector \( sec \) [ktoe]
- \( ESVD_{sec,esc} \): Energy service demand of service \( esc \) by sector \( sec \) [ktoe]
- \( FS_{sec,esc,e} \): Fuel share of fuel \( e \), service \( esc \) by sector \( sec \) [-]
- \( ED_{sec,esc,e} \): Energy demand of service \( esc \), fuel \( e \) by sector \( sec \) [ktoe]
- \( EE_{sec,esc,e} \): Energy efficiency of fuel \( e \), service \( esc \), sector \( sec \) [-]
- \( sec \): Sector
- \( esc \): Service
- \( e \): Fuel

(4) Energy demand
\[ ED_{sec,esc,e} = ESVD_{e,sec,esc} \times EE_{sec,esc,e} \] (13)
Where,
- \( ED_{sec,esc,e} \): Energy demand of service \( esc \), fuel \( e \) by sector \( sec \) [ktoe]
- \( ESVD_{e,sec,esc,e} \): Energy service demand by fuel \( e \), of service \( esc \), by sector \( sec \) [ktoe]
- \( EE_{sec,esc,e} \): Energy efficiency of fuel \( e \), service \( esc \), sector \( sec \) [-]
- \( sec \): Sector
- \( esc \): Service
\( e \) : Fuel

**Carbon accumulation**

\[
CO2_{\text{acm}} = \text{Tree} \times CA
\]

Where,
- \( CO2_{\text{acm}} \) : Accumulated CO\(_2\) by trees [tCO\(_2\)]
- \( \text{Tree} \) : The number of trees existing in the area [tree.]
- \( CA \) : CO\(_2\) accumulation ability per tree [tCO\(_2\)/tree]

**Dispersed power generation**

\[
ED_{dpg_{\text{sec}}} = EE_{dpg_{\text{sec}}} \times \text{Dif}_{dpg_{\text{sec}}}
\]

Where,
- \( ED_{dpg_{\text{sec}}} \) : Energy demand for electricity generated by dispersed power generation [ktoe]
- \( EE_{dpg_{\text{sec}}} \) : Performance of dispersed power generation [ktoe/m\(^2\)]
- \( \text{Dif}_{dpg_{\text{sec}}} \) : Diffusion of dispersed power generation [m\(^2\)]

**CO\(_2\) emission**

\[
CO2_{\text{sec,e}} = \bigg( \sum_{\text{sec,devcon}} ED_{\text{sec,devcon}} \bigg) \times ED_{dpg_{\text{sec}}} \times \text{CO2EF}_e - CO2_{\text{acm}}
\]

Where,
- \( CO2_{\text{sec,e}} \) : CO\(_2\) emission [tCO\(_2\)]
- \( ED_{dpg_{\text{sec}}} \) : Energy demand for electricity generated by dispersed power generation [ktoe]
- \( \text{CO2EF}_e \) : CO\(_2\) emission factor of fuel e [tCO\(_2\)/ktoe]
- \( CO2_{\text{acm}} \) : Accumulated CO\(_2\) by trees [tCO\(_2\)]

**Abatement cost**

(1) Devices

\[
\text{DESVD}_{\text{sec,devcon}} = \text{ESVD}_{\text{sec,devcon}} \times \text{Dif}^{\text{Bad}}_{\text{sec,devcon}}
\]

\[
\text{DESVD}_{\text{sec,devcon}} = \text{ESVD}_{\text{sec,devcon}} \times \text{Dif}^{\text{CM}}_{\text{sec,devcon}}
\]
\[ UD_{sec,esc,dev} = \frac{DESVD_{sec,esc,dev}}{SQ_{sec,esc,dev}} \]  

\[ CST\_dev_{sec,esc} = \sum_{dev} (UD_{sec,esc,dev} \times CSTuni\_dev_{sec,esc,dev} / LT\_dev_{sec,esc,dev}) - \sum_{devcon} (UD_{sec,esc,devcon} \times CSTuni\_dev_{sec,esc,devcon} / LT\_dev_{sec,esc,devcon}) \]

Where,

- \( DESVD_{sec,esc,dev} \): Energy service demand by sector \( sec \), service \( esc \), device \( dev \) [ktoe]
- \( \text{Diff}^{\text{BaU}}_{sec,esc,dev} \): Diffusion rate of device \( dev \) in sector \( sec \), service \( esc \) in BaU case [-]
- \( \text{Diff}^{\text{CM}}_{sec,esc,dev} \): Diffusion rate of device \( dev \) in sector \( sec \), service \( esc \) in CM case [-]
- \( UD_{sec,esc,dev} \): Unit demand of device \( dev \) in sector \( sec \), service \( esc \) [no.]
- \( SQ_{sec,esc,dev} \): Supply quantity per unit of device \( dev \) in sector \( sec \), service \( esc \) [ktoe/unit]
- \( CST\_add_{sec,esc} \): Additional cost in sector \( sec \), service \( esc \) [Thou.monetary]
- \( CSTuni\_dev_{sec,esc,dev} \): Cost to introduce a unit of device \( dev \) in sector \( sec \), service \( esc \) [Thou.monetary/unit]
- \( LT\_dev_{sec,esc,dev} \): Life time of device \( dev \) in sector \( sec \), service \( esc \) [year]

- \( sec \): Sector
- \( esc \): Service
- \( dev \): Device
- \( devcon \): Conventional device
- \( devhe \): High efficiency device

(2) Dispersed power generation equipment

\[ CST\_dpg_{sec} = \left( ESVD\_\ dpg_{sec} / ES\_R_{sec} \times CSTuni\_dpg_{sec} \right) / LT\_dpg_{sec} \]

Where,

- \( CST\_dpg_{sec} \): Additional cost to introduce dispersed power generation equipment [Thou.monetary/year]
- \( ESVD\_dpg_{sec} \): Energy service demand from dispersed power generation equipment in sector \( sec \) [ktoe]

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ES_{R_{sec}} : Annual Energy yield per rated system power [kWh/kW]

CSTuni_{dpg_{sec}} : Cost to introduce dispersed power generation equipment per rated system power in sector sec [Thou.monetary/kW]

LT_{dpg_{sec}} : Life time of dispersed power generation equipment in sector sec [year]

sec : Sector

(3) Smart grid

\[ CST_{bat_{sec}} = \left( \frac{RESVD_{sec} \times Cap_{sec} \times CSTuni_{bat_{sec}}}{LT_{bat_{sec}}} \right) \]  

(22)

Where,

\[ CST_{bat_{sec}} : \text{Additional cost to introduce battery [Thou.monetary/year]} \]

\[ Cap_{sec} : \text{Needed capacity of battery per rated system power of dispersed power generation equipment in sector sec [kWh/kW]} \]

\[ CSTuni_{bat_{sec}} : \text{Cost to introduce battery per capacity in sector sec [Thou.monetary/kW]} \]

\[ LT_{bat_{sec}} : \text{Life time of battery in sector sec [year]} \]

sec : Sector

(4) Reduction of energy cost

\[ CST_{e_{sec}} = \left( \sum_{sec, esc} ED^{bat}_{esc, sec, e} - \sum_{sec, esc} ED^{CM}_{esc, sec, e} \right) \times CSTuni_{e_{sec}} / 10^6 \]  

(23)

Where,

\[ CST_{e_{sec}} : \text{Reduced energy cost of fuel e [Mill. US$]} \]

\[ ED_{sec, esc, e} : \text{Energy demand of service esc, fuel e by sector sec [ktoe]} \]

\[ CSTuni_{e_{sec}} : \text{Cost of energy [US$/ktoe]} \]

sec : Sector

esc : Service

e : Fuel