Study on Sustainable Low Carbon Society in Malaysian Regional Development

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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 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. 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 buring of fossil fuels have contributed to increases in the atmospheric concerntrations of Carbon dioxide (CO_2). CO_2 is one of the more significant and long-lived GHG (IPCC 2001). The othe 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 CO_2 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 consolidationg 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 CO_2 emission in economy develepment is the main target.

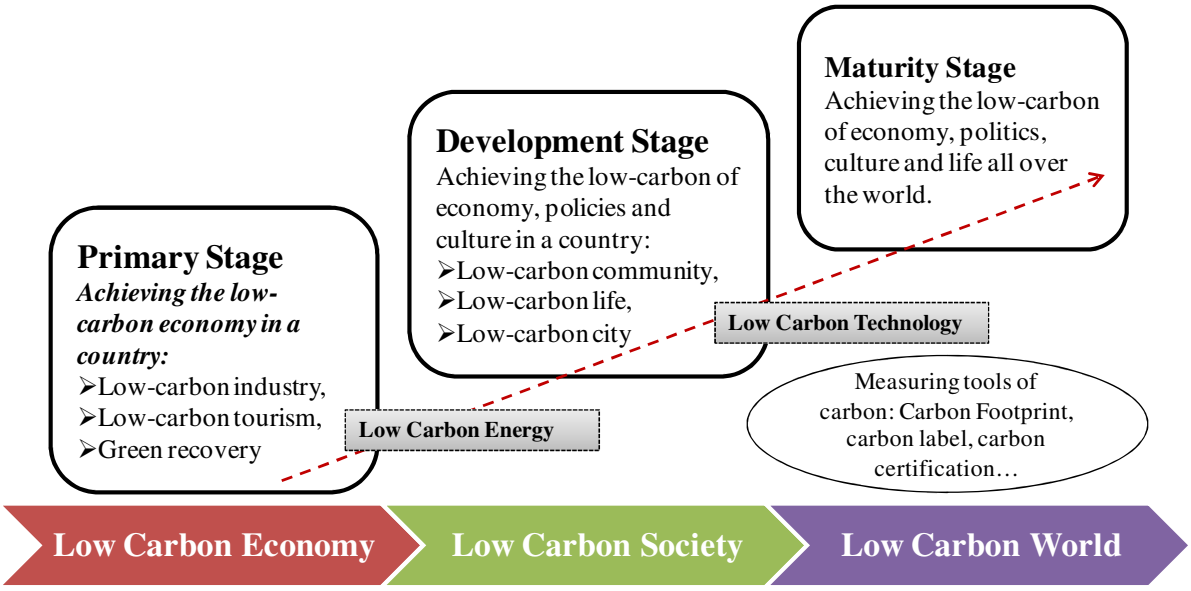

Figure 1.1: The phases of low carbon development

Source: (Hu, Peng and Dequn 2011)

The second phase is the development stage known as low carbon society (LCS) . During this phase govenments should try to promote low carbon lifestyles and consumption pattens. 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 intoduction of new energy resources such as renewble energy sources and the implementation of energy efficency in appliences 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 severall 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.

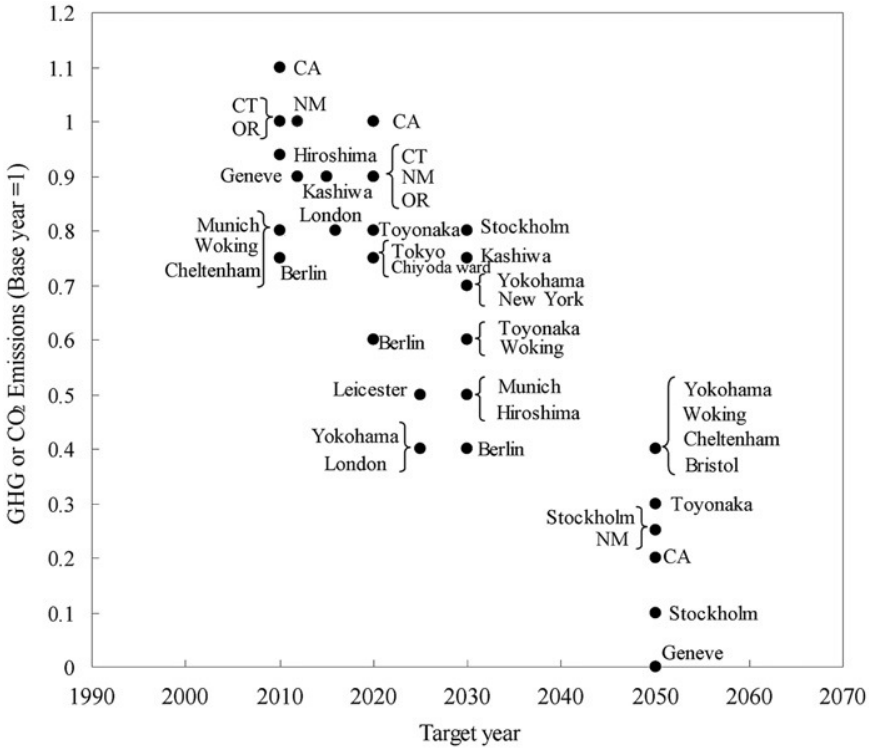

Figure 1.2: Low carbon targets of the local governments around the world

Note: The emission reduction targets are shown in relative emission amount compared to base-year emission of each municipality. The base year, target gases and target activities vary among the municipalities. Abbreviations of names of states in the US are: CA; California, CT: Connecticut, NM; New Mexico, OR: Oregon

Source: (Gomi, Shimada, & Matsuoka, A Low-carbon scenario creation method for a local-scale economy and its application in Kytot City, 2010)

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 canididates 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 implememntation 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 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)

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)

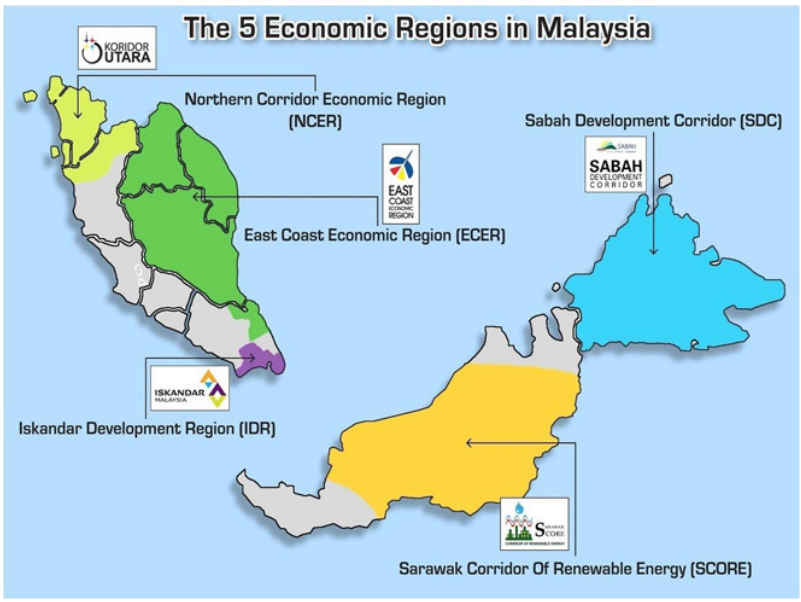

Figure 1.3: Location of five (5) economic development corridors in Malaysia

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.

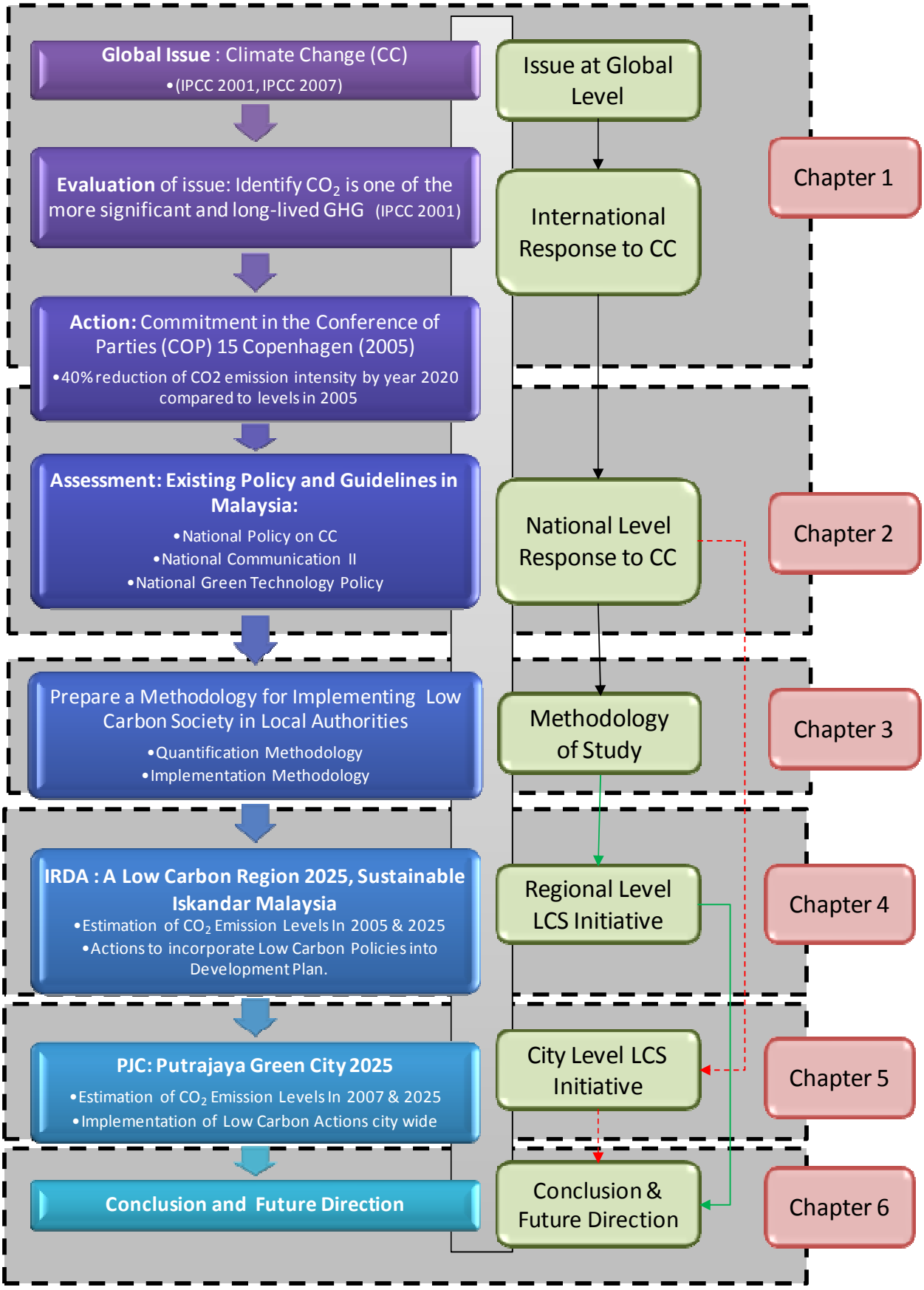

Figure 1.4: Flow of Research Framework

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

Adams, W. M. (2009). *Green Development. Environment and sustainability in a developing world* (3rd Edition ed.). New York: Routledge.

Economic Planning Unit . (2010a). *Tenth Malaysian Plan 2011-2015.* Putrajaya: PNMB.

Economic Planning Unit. (2006). *Ninth Malaysian Plan 2006-2010.* Putrajaya: EPU.

Federal Department of Town & Country Planning. (2010). *National Physical Plan 2.* Kuala Lumpur: Ministry of Housing & Local Government.

Federal Dept. of Town & Country Planning. (2009). *A Guide for Conductiong Focus Group Discussions, Charrettes and Village Appraisals.* Kuala Lumpur: JPBD.

Federal Dept. of Town & Country Planning. (2006). *National Urbanization Plan.* Kuala Lumpur: JPBD.

Gomi, K., Shimada, K., & Yuzuru, M. (2010). A Low-carbon Scenario Creation Method for a Local-scale Economy and its application in Kyoto City. *Energy Policy* , 4783-4796.

Hu, Y., Peng, Z., & Dequn, Z. (2011). What is low-carbon development? A conceptual analysis. *Energy Procedia* , 1706-1712.

IPCC. (2001). *Climate Change 2001: Impacts, Adaptions and Vulnerability, Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change.* New York, NY: Cambridge University Press.

IPCC. (2007b). *Climate Change 2007: Impacts, adaptation and vulnerability* (Contribution of Working Groups II to the Forthd Assessment Report of the Intergovernmental Panel on Climate Change ed.). (M. L. Parry, O. Canziani, J. Palutikof, V. d. Linden, & C. E. Hanson, Eds.) Cambridge & New York: Cambridge University Press.

IPCC. (2007a). *Climate Change 2007: Mitigation of Climater change.* (O. Davidson, P. Bosch, R. Dave, L. Meyer, & B. Metz, Eds.) Cambridge and New York: Cambridge University Press.

IPCC. (2007). *Climate Change 2007: Syntesis report* (Contribution of Working Groups I, II, and III to the Forthd Assessment Report of the Intergovernmental Panel on Climate Change ed.). (R. K. Pachauri, & A. Reisinger, Eds.) Cambridge & New York: Cambridge University Press.

Kawase, R., Matsuoka, Y., & Fujino, J. (2006). Decomposition analysis of CO2 emission in long-term climate stabilization scenarios. *Energy Policy , 34*, 2113-2122.

Ministry of Natural Resource & Environment Malaysia. (2009). *National Policy on Climate Change.* Putrajaya: NRE Malaysia.

National Economic Advisory Council. (2010). *New Economic Model for Malaysia.* Putrajaya: Pencetak Nasional Malaysia Bhd. (PNMB).

New Horizons in Regional Science. (2006). *Regional Climate Change and Variability. Impacts and Responses.* (R. Matthias, D. Kieran, & K. Paul, Eds.) Cheltenham U.K & Massachusettes USA: Edward Elgar Publishing Limited.

PEMANDU. (2010). *Government Transformation Plan.* Kuala Lumpur: Pencetakan Nasional Malaysa Bhd.

Project Management Institute, Inc. (2008). *A Guide to the Project Management Body of Knowledge- Fourth Edition.* Pennsylvania, USA: Project Management Institute, Inc.

Robert, G. B., Selma, H., Susan, H., James, T., & Graham, W. (2005). *Sustainability Assessment, Criteria and Processes.* London: Earthscan.

Simon, B., & Stephan, M. (2008). *Sustainability Indicators, Measuring the Immeasurable?* London: Earthscan.

Simson, J. J., Ho, S. C., Matsuoka, Y., & Gomi, K. (2011a). Planning Sustainable Development in Malaysia by Incorporating the Concept of Low Carbon Society. *11th International Congress of Asian Planning Schools Association 2011.* Tokyo: APSA.

Simson, J. J., Ho, S. C., Matsuoka, Y., & Gomi, K. (2011). Roadmap of Low Carbon City Development in Malaysia- The Iskandar Malaysia Regional Development Experience. *3rd World Planning Schools Congress* (pp. 1-14, Track 20). Perth: WPSC .

Smith, P. F. (2010). *Building for a Changing Climate, The Challenge for Construction, Planning & Energy.* London: Earthscan.

UN . (2010). *World Urbanization Prospects: 2009 Revision*. Retrieved November 25, 2011, from http://esa.un.org/unpd/wup/Documents/WUP2009_Highlights_Final.pdf

UN Habitat. (2011). *Cities & Climate Change; Global Report on Human Settlement 2011.* London: Earthscan.

V.R, S. (2011). Sustaining Cities with Climate Change. In B. Yuen, & G. Ooi, *World Cities-Achieving Livability and Vibrancy.* (p. Chapter 11). Singapore: World Scientific Pulblishing Co Pte. Ltd, Singapore.

Whitmarsh, L., Gill, S., & Saffron, O. (2011). Public engagement with carbon and climate change: To what extent is the public 'carbon capable'? *Global Environment Change , 21*, 56-65.

2 A MALAYSIAN OUTLOOK

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 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.

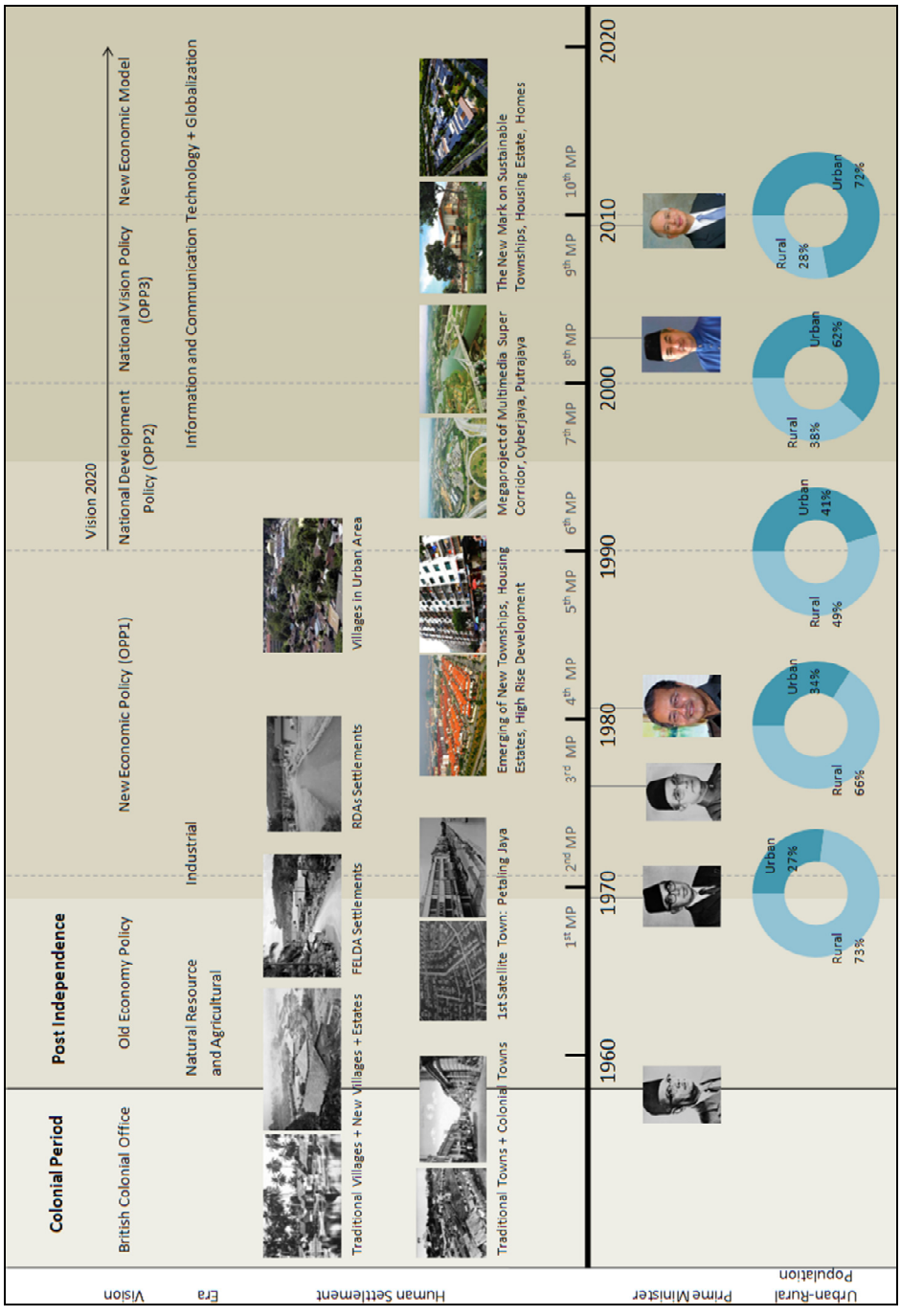

Figure 2.1: Evolution of Sustainable Development and Urban Population from 1960-2020 in Malaysia

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: (Ministry of Energy, Green Technology & Water, 2009)

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 CO_2 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 CO_2 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 CO_2 emission in Malaysia.

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

Sectors	1990	1995	2000	2005	2006	2007
Agriculture	-	446	104	101	258	281
Non-Energy	908	2,994	2,250	2,173	2,809	2,958
Residential & Commercial	1,646	2,837	3,868	5,134	5,430	6,196
Transport	5,387	7,827	12,071	15,384	14,825	15,717
Industrial	5,276	8,060	11,406	15,492	17,002	19,116
Total	**13,217**	**22,164**	**29,699**	**38,284**	**40,324**	**44,268**

Source: 2nd National Communication Report 2011

Figure 2.3 shows the Source of CO_2 emission in Malaysia, a total of 167.44Mton of CO_2 was emitted. Emission from energy industries has the highest emission with 58.48Mton CO_2; 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.

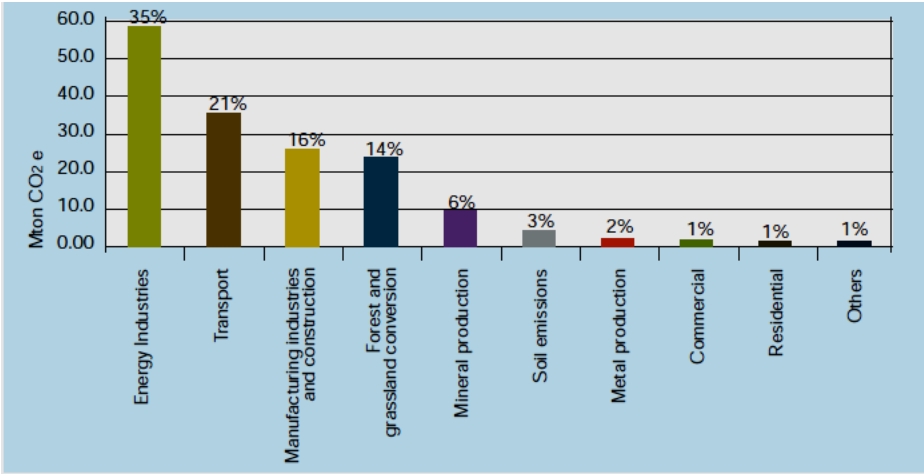

Figure 2.3: Source of CO_2 Emission in Malaysia 2000

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.

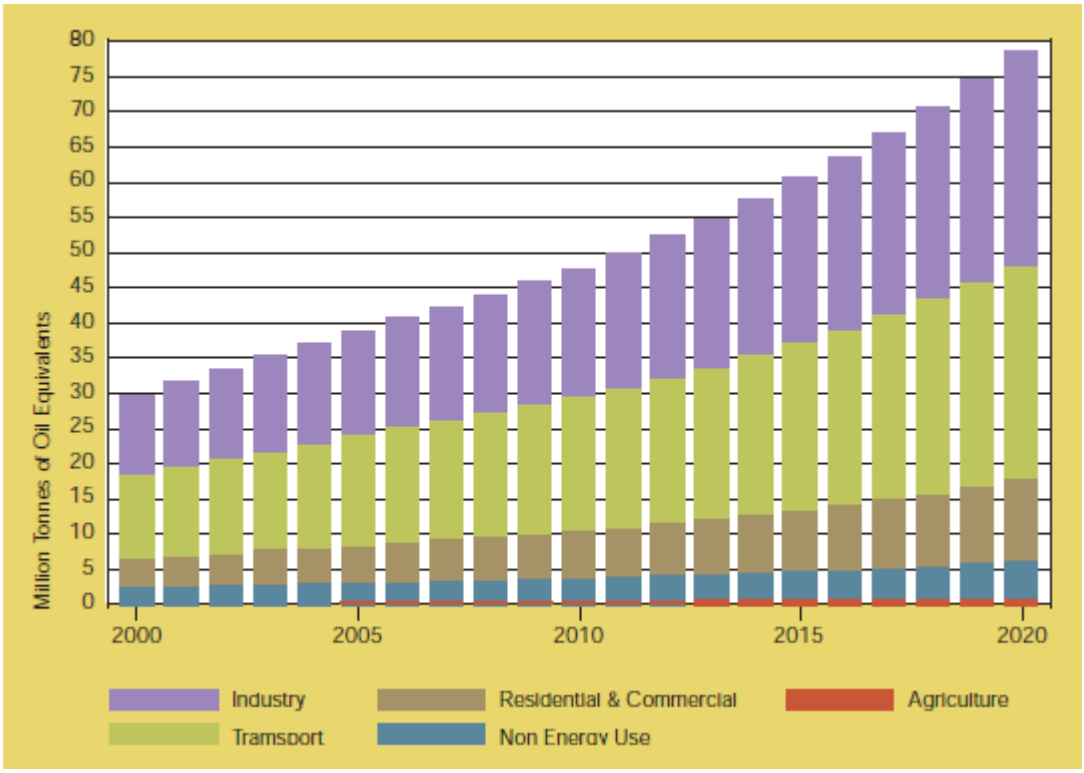

Figure 2.4: Final Energy Demand by Sectors in BaU Scenario, 2000-2020

Source: 2nd National Communication Report 2011

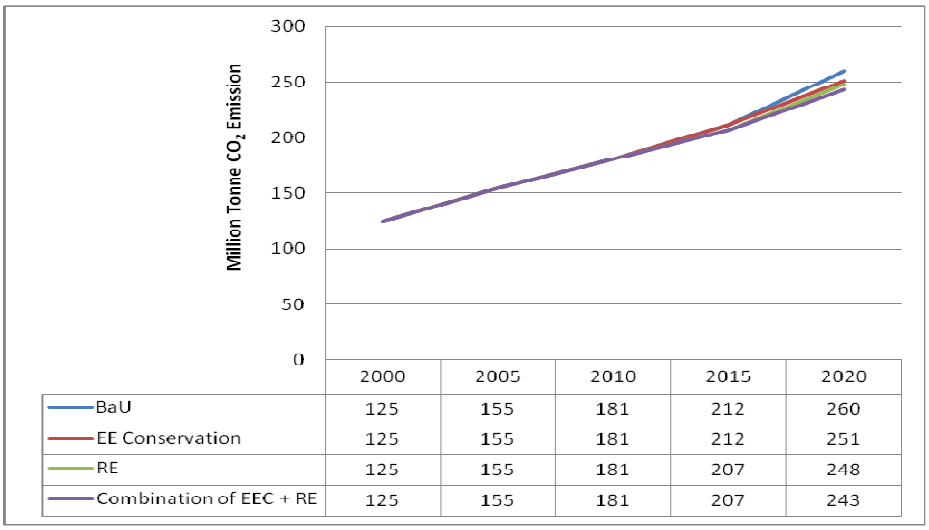

Figure 2.5: CO_2 Emission Projection by Scenarios, 2000-2020

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 CO_2 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 CO_2 per US$1000 of GDP is also higher than the world average of 0.73 tonne of CO_2 per US$1000 of GDP.

Table 2.2: CO_2 emission per capita and emission intensity of selected countries, 2007

Countries	Emission per capita tones of CO_2 per capita	Emission Intensity tones of CO_2 per US$1000 of GDP
World	**4.35**	**0.73**
United States	19.1	0.5
Singapore	9.8	0.3
Japan	9.7	0.2
United Kingdom	8.6	0.3
Malaysia	6.7	1.3
China	4.6	2.5
Thailand	3.5	1.3
Indonesia	1.7	1.6
India	1.2	1.7

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

Bruton, M. J. (2007). *Malaysia The Planning of a Nation.* Kuala Lumpur: PERSADA .

Economic Planning Unit . (2010a). *Tenth Malaysian Plan 2011-2015.* Putrajaya: PNMB.

Economic Planning Unit. (2006). *Ninth Malaysian Plan 2006-2010.* Putrajaya: EPU.

Federal Department of Town & Country Planning. (2010). *National Physical Plan 2.* Kuala Lumpur: Ministry of Housing & Local Government.

Federal Dept. of Town & Country Planning. (2006). *National Urbanization Plan.* Kuala Lumpur: JPBD.

Gomi, K., Ochi, Y., & Matsuoka, Y. (2011). A systematic quantitative backcasting on low-carbon society policy in case of Kyoto City. *Technological Forecasting & Social Change* .

IPCC. (2001). *Climate Change 2001: Impacts, Adaptions and Vulnerability, Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change.* New York, NY: Cambridge University Press.

IPCC. (2007b). *Climate Change 2007: Impacts, adaptation and vulnerability* (Contribution of Working Groups II to the Forthd Assessment Report of the Intergovernmental Panel on Climate Change ed.). (M. L. Parry, O. Canziani, J. Palutikof, V. d. Linden, & C. E. Hanson, Eds.) Cambridge & New York: Cambridge University Press.

IPCC. (2007a). *Climate Change 2007: Mitigation of Climater change.* (O. Davidson, P. Bosch, R. Dave, L. Meyer, & B. Metz, Eds.) Cambridge and New York: Cambridge University Press.

IPCC. (2007). *Climate Change 2007: Syntesis report* (Contribution of Working Groups I, II, and III to the Forthd Assessment Report of the Intergovernmental Panel on Climate Change ed.). (R. K. Pachauri, & A. Reisinger, Eds.) Cambridge & New York: Cambridge University Press.

Khazanah National. (2006). *Comprehensive Development Plan for South Johor Economic Region 2006-2025.* Kuala Lumpur: Khazanah National.

Malaysian Green Technology Corporation (MGTC). (2010). *National Energy Balance Table 2009.* Putrajaya: Ministry of Energy, Green Technology & Water, Malaysia (KeTTHA).

Ministry of Energy, Green Technology & Water. (2009). *National Green Technology Policy.* Putrajaya: KeTTHA.

Ministry of Natural Resource & Environment Malaysia. (2011). *Malaysia, Second National Communication to the UNFCCC.* Putrajaya: NRE Malaysia.

Ministry of Natural Resource & Environment Malaysia. (2009). *National Policy on Climate Change.* Putrajaya: NRE Malaysia.

MOE, Japan. (n.d.). *Ministry of Environment, Government of Japan*. Retrieved 10 20, 2011, from Building a Low Carbon Society: http://www.env.go.jp/en/earth/

National Economic Advisory Council. (2010). *New Economic Model for Malaysia.* Putrajaya: Pencetak Nasional Malaysia Bhd. (PNMB).

PEMANDU. (2010). *Government Transformation Plan.* Kuala Lumpur: Pencetakan Nasional Malaysa Bhd.

Simson, J. J., Ho, S. C., Matsuoka, Y., & Gomi, K. (2011a). Planning Sustainable Development in Malaysia by Incorporating the Concept of Low Carbon Society. *11th International Congress of Asian Planning Schools Association 2011.* Tokyo: APSA.

Simson, J. J., Ho, S. C., Matsuoka, Y., & Gomi, K. (2011). Roadmap of Low Carbon City Development in Malaysia- The Iskandar Malaysia Regional Development Experience. *3rd World Planning Schools Congress* (pp. 1-14, Track 20). Perth: WPSC .

Simson, J., Ho, S. C., Matsuoka, Y., & Gomi, K. (2010). Development of Low Carbon City in Malaysia.- The Case of development corridor of Iskandar Malaysia. *First International Conference on SUstainable Urbanization (ICSU 2010)* (pp. 1-12). Hong Kong : Hong Kong Polytechnic University.

Simson, J., Ho, S. C., Matsuoka, Y., & Gomi, K. (2011b). Low Carnon Urban Development Strategy in Malaysia. The Case of Iskandar Malaysia Development Corridor. *Habitat International- A Journal for the Study of Human Settlements* .

Skea, J., & Nishioka, S. (2008). Policies and practices for a low-carbon society. *Climate Policy* .

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 3.4and 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.

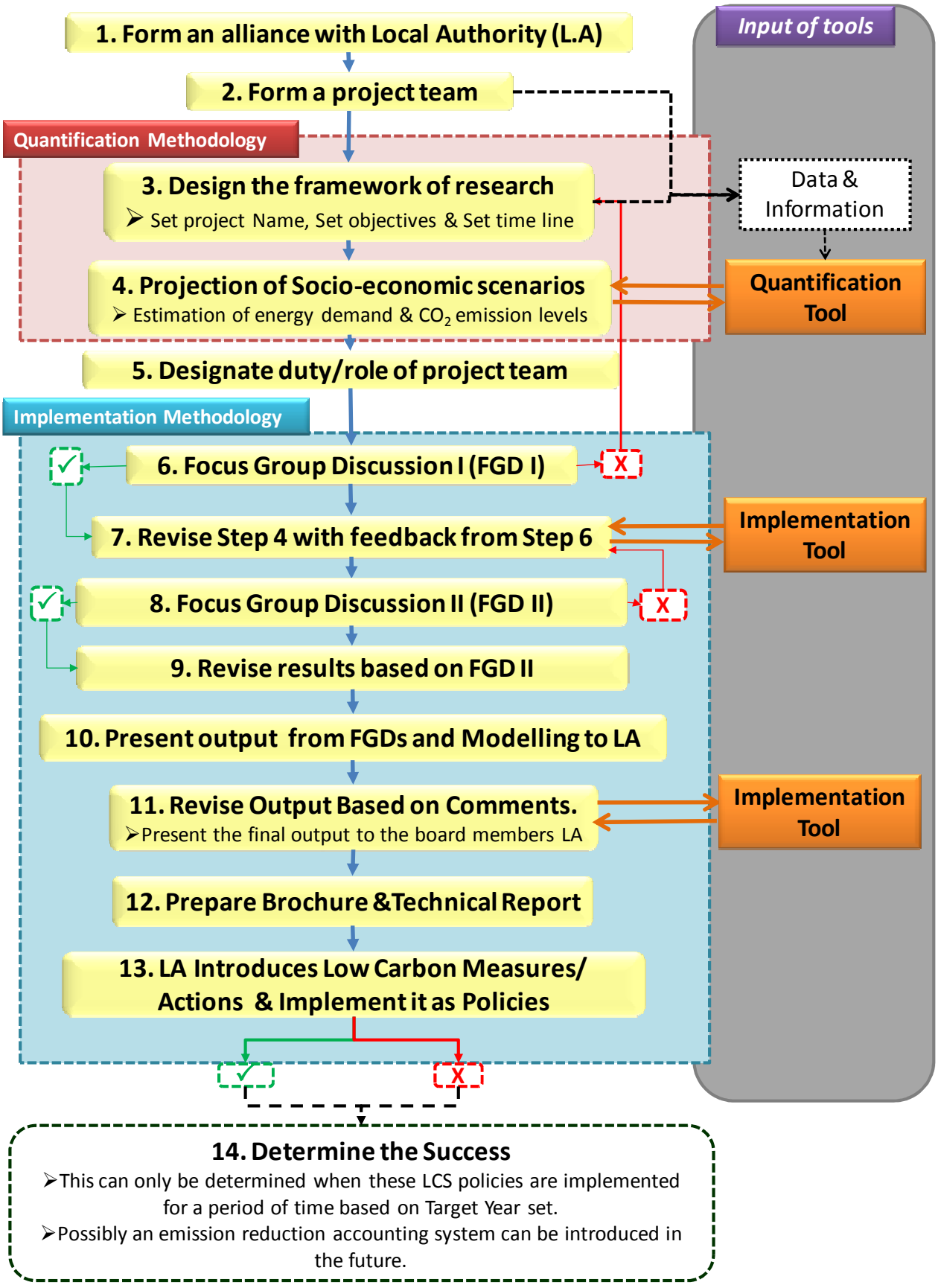

Figure 3.1: Methodology of Low Carbon Society Development

(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.

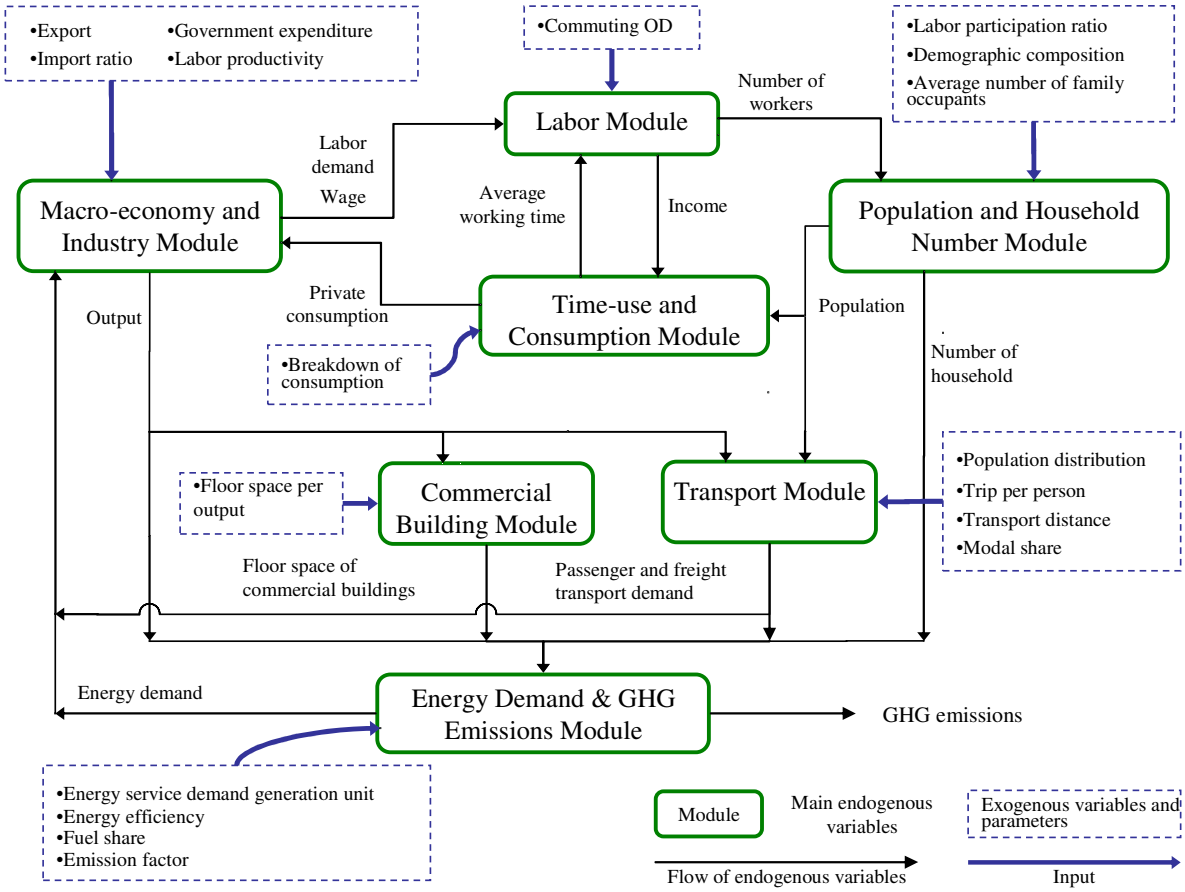

Figure 3.2: The Structure of ExSS

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, 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 3.3. The details of this Model structure are attached to Appendix.

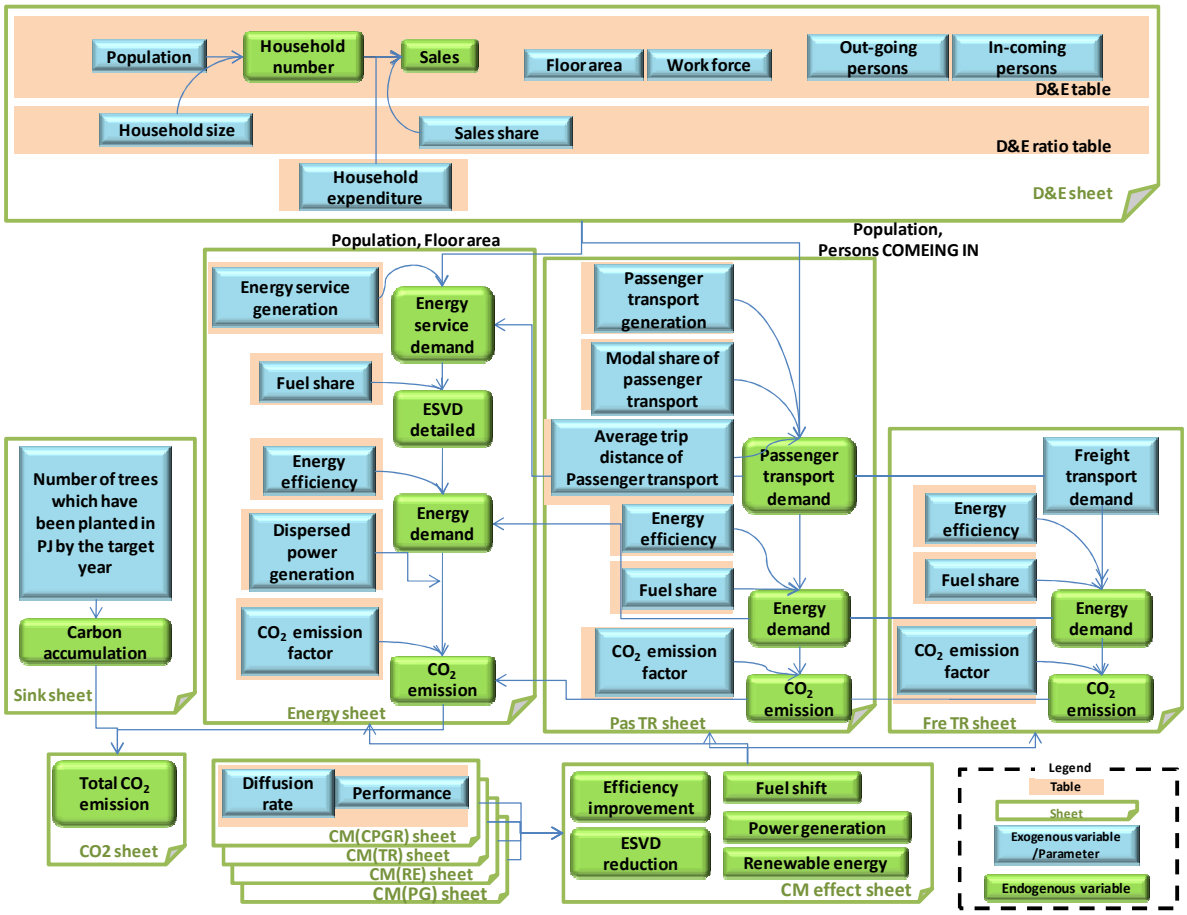

Figure 3.3: Structure of C-ExSS

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 CO_2 emissions in the base year is calculated. The third step is when the CO_2 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.

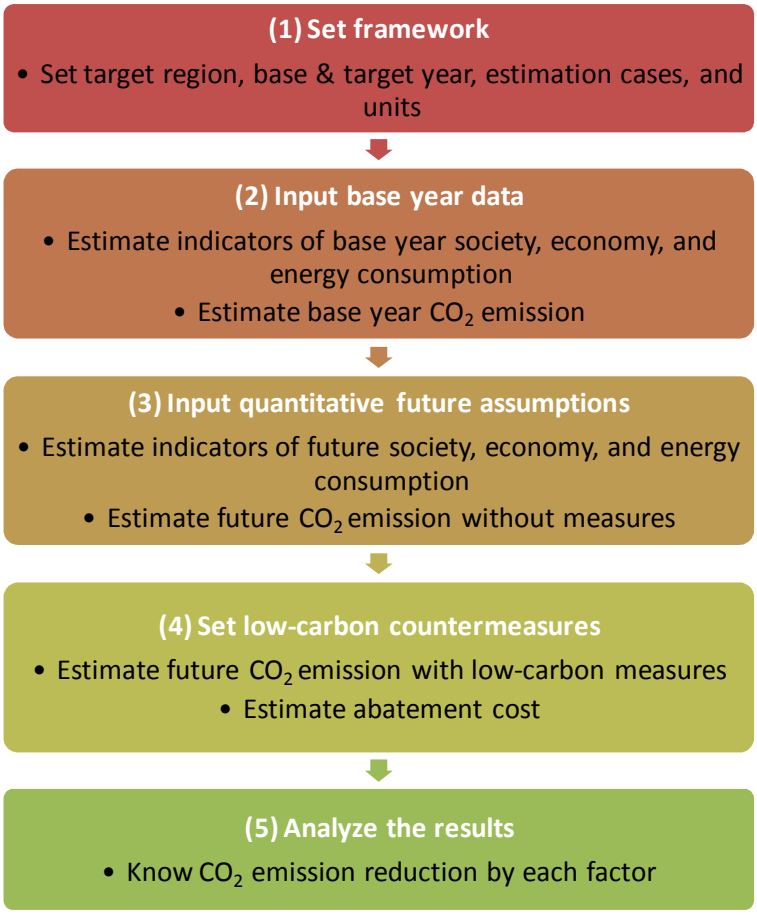

Figure 3.4: The Calculation Procedure in C-ExSS

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 stake holders. 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 CO_2 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 see in Figure 3.5. This steps that need to be taken 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)

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.

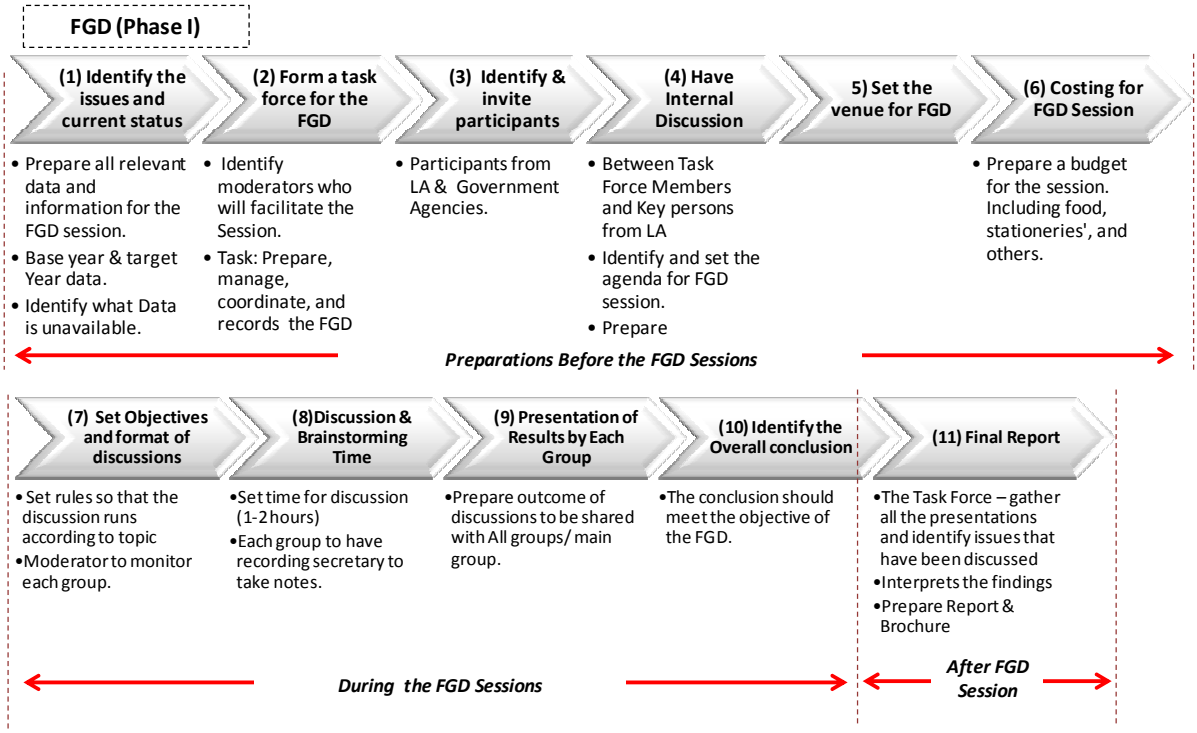

Figure 3.5: Structure of Focus Group Discussion I

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.

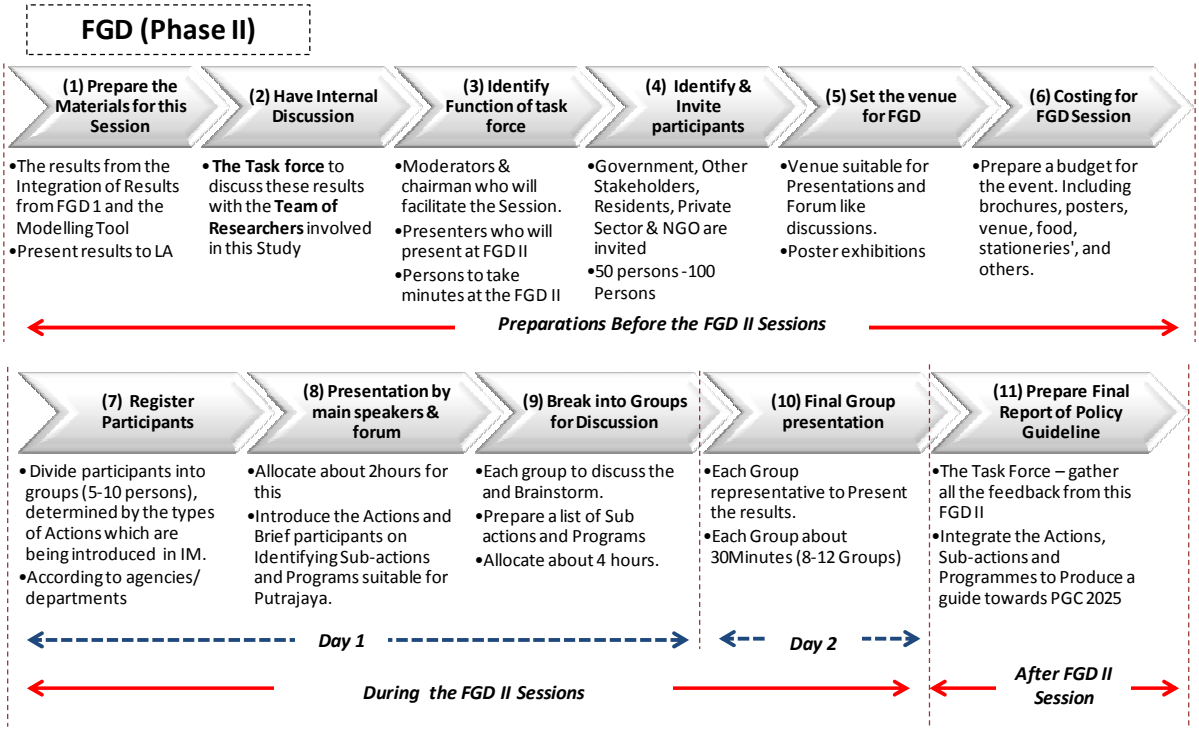

Figure 3.6: Structure of Focus Group Discussion II

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:

<u>Event on Day one:</u>

(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.

(11) 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

A, K. R. (1988). *Focus Groups: A practical guide for applied research.* California, USA: Sage Publications. Inc.

Escalda, M., & Hong, K. (2007). *Focus Group Discussion.*

Federal Dept. of Town & Country Planning. (2009). *A Guide for Conductiong Focus Group Discussions, Charrettes and Village Appraisals.* Kuala Lumpur: JPBD.

Gomi, K., Ochi, Y., & Matsuoka, Y. (2011). A systematic quantitative backcasting on low-carbon society policy in case of Kyoto City. Technological Forecasting & Social Change .

Gomi, K., Shimada, K., & Yuzuru, M. (2010). A Low-carbon Scenario Creation Method for a Local-scale Economy and its application in Kyoto City. Energy Policy , 4783-4796.

Kawase, R., Matsuoka, Y., & Fujino, J. (2006). Decomposition analysis of CO2 emission in long-term climate stabilization scenarios. Energy Policy , 34, 2113-2122.

Lindsey, G., Joel, T. A., & Sheila, H. J. A Handbook for planning and Conductiong Charrettes for high-preformance projects. National Renewable Energy Labrotory U.S.

Project Management Institute, Inc. (2008). *A Guide to the Project Management Body of* Knowledge- Fourth Edition. Pennsylvania, USA: Project Management Institute, Inc.

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.

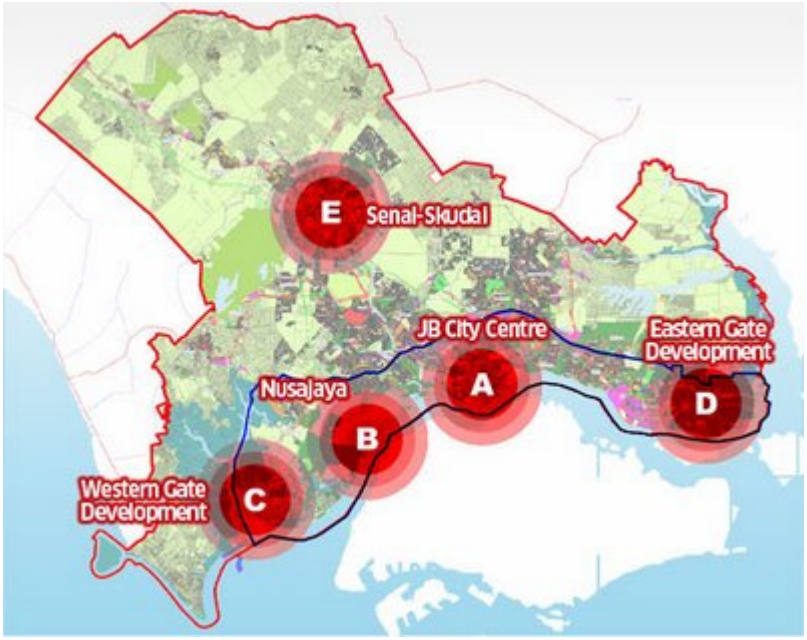

Figure 4.1: The Flagship Zones within Iskandar Malaysia

Source: Iskandar Regional Development Authority.

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

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)

- Malaysian Green Technology Corporation (MGTC)
- Iskandar Regional Development Authority (IRDA)

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_2 emission in Iskandar Malaysia. In accordance to this, measures required to reduce the per capita CO_2 emission from fuel combustion by 30% by 2025CM against the levels of 2005 and to reduce 50% of CO_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*

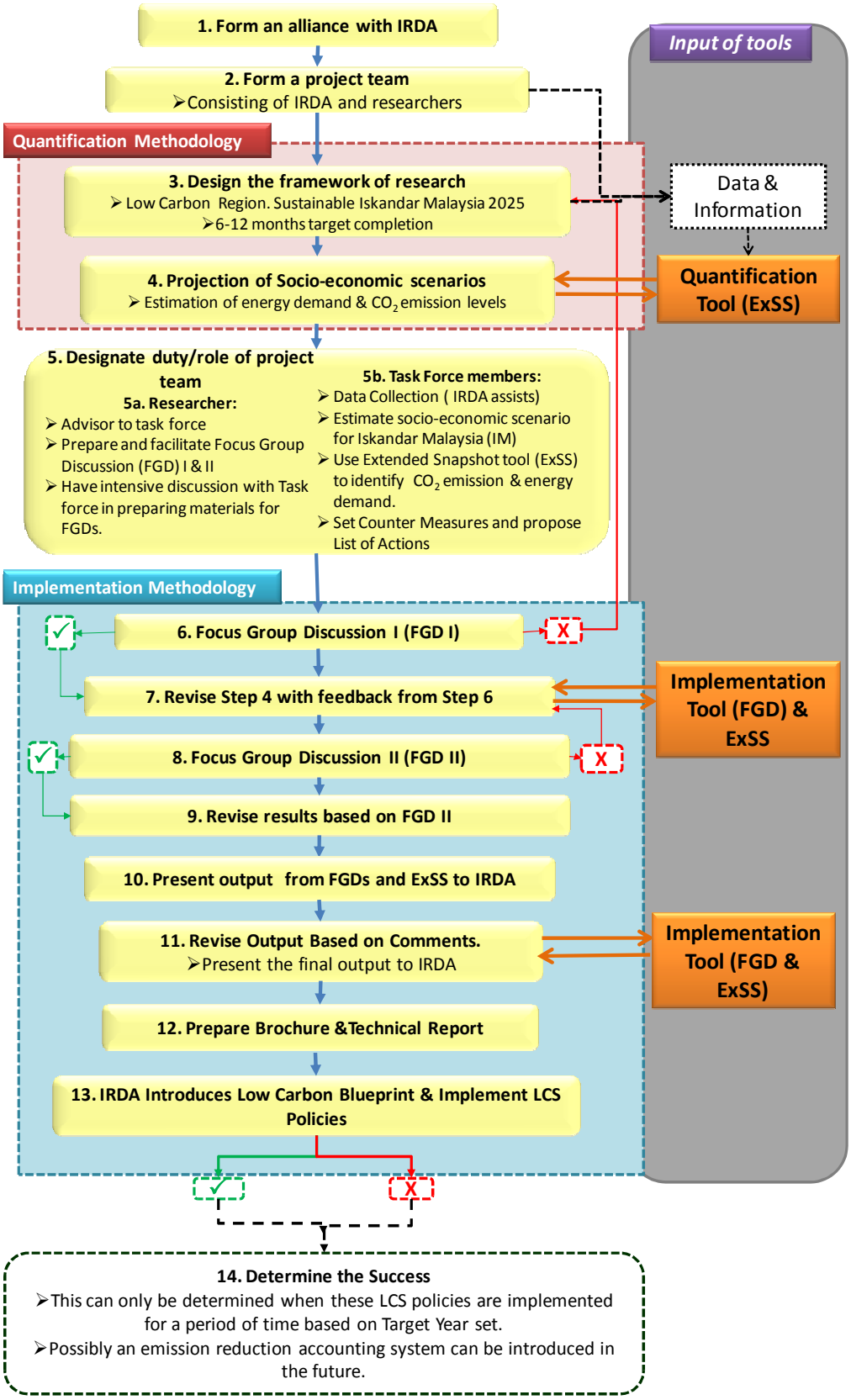

Figure 4.2: Methodology for developing a LCS for Iskandar Malaysia

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_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.

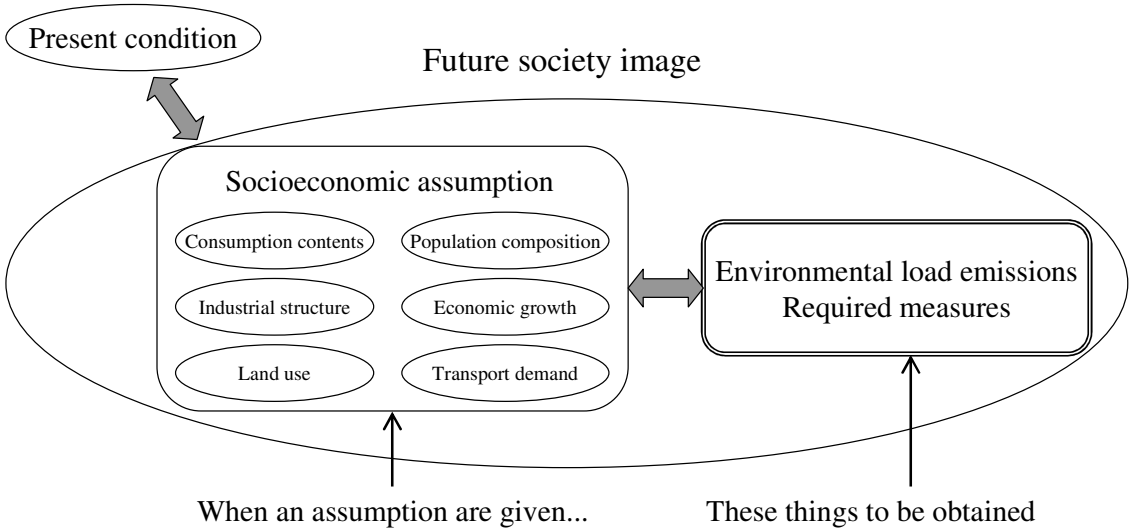

Figure 4.3: Outline of the problem establishment of LCS study

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.

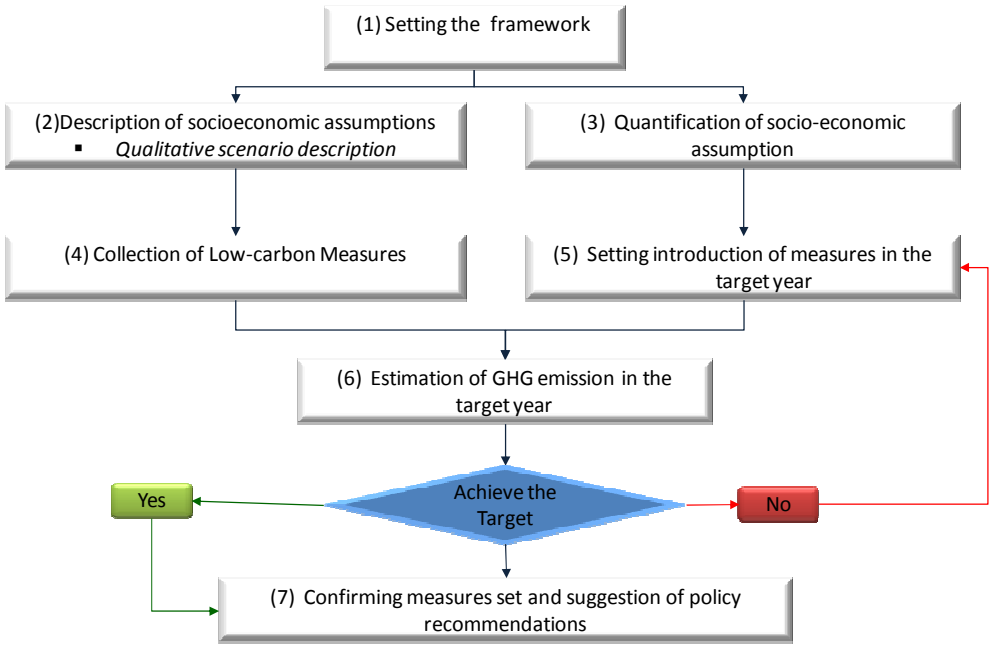

Figure 4.4: Procedure of LCS Study

(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 4.1: The main indices to set up (exogenous variables / parameter)

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

(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.

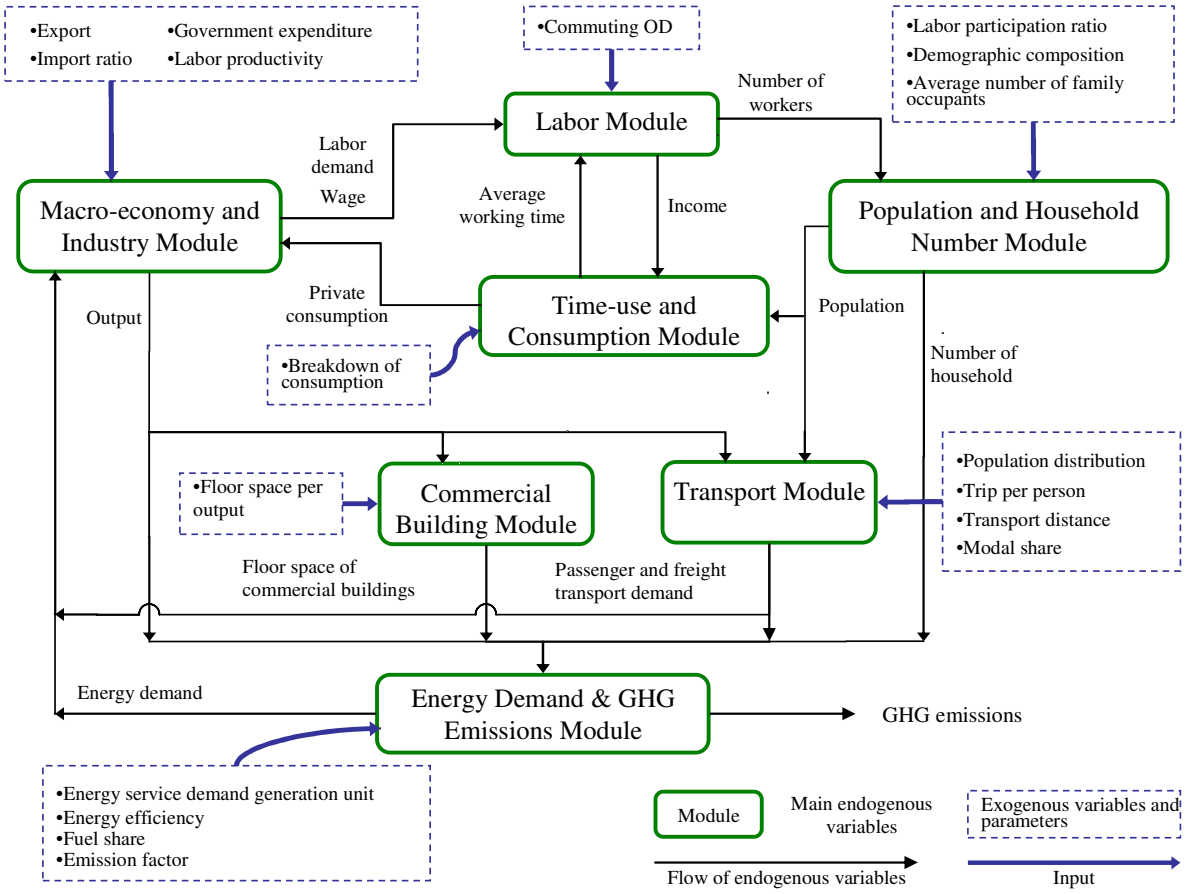

Figure 4.5: The estimation system of Extended Snapshot (ExSS) tool

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).

$$PTD_{ptm} = \sum_{sex}\sum_{age} Pop_{sex,age} \cdot PTG_{sex,age} \cdot PTS_{ptm} \cdot PTAD_{ptm} \cdot 365 \quad (4\text{-}1)$$

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 4.2: Data used in the data complement (Fulton and Eads, 2004)

Mode	Annual mileage per vehicle (km/vehicle/year)	No. of passengers carried by transport per vehicle per trip (person/vehicle/trip)
Motorcar	10,000	1.89
Motorcycle	10,000	1.65
Bus	40,000	18.75

- 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.

[Passenger transport volume in IM (passenger-km)]

= [Passenger transport volume in Malaysia (passenger-km)] (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

	Railways	Bus	Motorcar	Motorcycle	Walk	Bicycle
Modal share	0.011	0.015	0.534	0.226	0.147	0.067

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

Unit: km/trip	Railways	Bus	Motorcar	Motorcycle	Walk	Bicycle
Average trip distance	1.8	4.0	4.0	4.0	1.0	2.5

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).

$$FTD_{ftm} = FTPD_{pss} \cdot FTG_{pss} \cdot FTS_{pss,ftm} \cdot FTAD_{ftm} \quad (4\text{-}6)$$

Where,

FTD_{ftm}: 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)

$FTS_{pss,ftm}$: modal share (freight) (-)

$FTAD_{ftm}$: 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 4.5: Data used in the data complement (Fulton and Eads, 2004)

Mode	Annual mileage per vehicle (km/vehicle)	Load tonnage per vehicle per trip (t/vehicle/trip)
Freight vehicle	31,480	2.93

- 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%; 3,699,000vehicles). 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%; 3,699,000vehicles). These reference values were from Fulton and Eads (2004).

• Freight railways

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

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

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

[No. of railways stations in IM (KTM)]/ [No. of railways stations in Malaysia (KTM)] (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 4.6: Modal share

	Freight railways	Freight vehicle
Modal share	0.003	0.997

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 4.7: Average trip distance by mode (freight)

Unit: km	Freight railways	Freight vehicle
Average trip distance	56.8	27.4

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 .

$$FA_{svs} = PD_{svs} \cdot FAG_{svs} \cdot FAGCR_{svs} \quad (4\text{-}11)$$

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

Commercial sector	Industry sector
Office	Transport related, Professional and Business, Other Services, Public administration
Shop	Wholesale and Retail, Tourism and Hospitality
Hospital & school	Medical and Education

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

m^2/mil RM	Floor space per output
Office	43
Shop	275
Hospital & school	315

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 4.10: Population by sex and age cohort

	0-14	15-64	65+
Male	208,547	454,017	21,197
Female	204,179	444,507	20,753

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.

[No. of households (2005)]

=[No. of households (2000)]

*[No. of places of residence (2005)]/[No. of places of residence (2000)] (4-12)

Table 4.11: The number of places of residence and households

	2000	2005
Places of residence	256,166	321,916
Households	212,836	317,762

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 .

Table 4.12: Labour-force participation ratio

(Department of Statistics, Malaysia, 2006b)

%	15-64	65+
Male	82.4	25.0
Female	46.0	20.0

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.

[No. of workers by industry in Iskandar Malaysia]
=[Breakdown of the number of workers by industry in Malaysia]
*[Compensation of employees by industry in Iskandar Malaysia (RM)]
/[Compensation of employees by industry in Malaysia (RM)] (4-13)

Table 4.13: The number of workers by industry

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

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.

$$ED_{eds,esc,e} = ESDF_{eds,esc} \cdot ESVG_{eds,esc} \cdot ES_{eds,esc} \cdot EE_{eds,esc,e} \quad (4\text{-}14)$$

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 4.14: Energy demand by fuel type of residential and commercial sector

Unit: ktoe	Coal	Petroleum	Gas	Renewables	Electricity	Total
Residential	0	47	0	0	193	240
Commercial	0	53	2	0	328	382

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 4.15: Basic units of energy service demand and fuel share (2005)

Sector	Energy service	Basic unit	Fuel share					
			Coal	Petroleum	Gas	Renewables	Electricity	Total
Residential		0.755 toe/household	0%	20%	0%	0%	80%	100%
Commercial		55.835 ktoe/mil m^2	0%	14%	0%	0%	86%	100%
Industry	Agriculture	1.636	0%	100%	0%	0%	0%	100%
	Mining	-	-	-	-	-	-	-
	Food Products and Bevarages	56.062	0%	31%	43%	0%	26%	100%
	Chemicals and Chemical Products	34.520	0%	64%	22%	0%	14%	100%
	Electric and Electronic Products and Machinery	8.394	0%	10%	56%	0%	34%	100%
	Fabricated Metal Products and Machinery	5.759	0%	31%	43%	0%	26%	100%
	Other Non-Metallic	23.337	40%	27%	21%	0%	13%	100%
	Rubber and Plastics Products	61.498	0%	56%	28%	0%	17%	100%
	Construction	10.950 ktoe/mil RM	0%	46%	34%	0%	20%	100%
Passenger transport	Passenegr railways	0.005	0%	0%	0%	0%	100%	100%
	Bus	0.521	0%	99%	1%	0%	0%	100%
	Motorcar	0.122	0%	99%	1%	0%	0%	100%
	Motorcycle	0.035 ktoe/mil p-km	0%	99%	1%	0%	0%	100%
Freight transport	Freight railways	0.006	0%	0%	0%	0%	100%	100%
	Freight vehicle	0.348 ktoe/mil t-km	0%	99%	1%	0%	0%	100%

4.6 Socioeconomic assumption

The socioeconomic assumption in 2025 which is the requisite for the estimation of energy demand and CO_2 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. n 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 4.16: Average number of household members

	2005	2025
No. of household members	4.26	4.00

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 4.17: Demographic composition by sex and age cohort

Age cohort	2005			2025		
	Male	Female	Total	Male	Female	Total
0-14	0.154	0.151	0.305	0.120	0.113	0.233
15-64	0.336	0.328	0.664	0.339	0.330	0.669
65+	0.016	0.015	0.031	0.045	0.054	0.098
Total	0.505	0.495	1.000	0.504	0.496	1.000

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 4.18: Labour-force participation ratio

Age cohort	Male		Female	
	2005	2025	2005	2025
15-64	82%	90%	46%	60%
65+	25%	30%	20%	25%

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

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

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)

Final demand sector	2005	2025	2025/2005	Annual growth rate
Private consumption expenditure	1,0194	6,8578	6.73	10%
Government consumption expenditure	2,812	18,916	6.73	10%
Gross fixed capital formation	4,589	31,034	6.76	10%

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 4.21 Percentage distribution of private consumption expenditure

	2005	2025
Primary industry	8%	4%
Secondary industry	45%	42%
Tertiary industry	47%	54%

Table 4.22: The final demand converter

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

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 4.23: Primary energy composition of national electricity supply

	Coal-fired thermal	Oil-fired thermal	Gas-fired thermal	Hydro	Renewables	Total
2005	26.5%	2.9%	64.0%	6.6%	0.0%	100.0%
2025	47.5%	0.5%	46.5%	5.0%	0.5%	100.0%

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 4.24: Other settings

	Unit	2005	2025
Propensity to consume	-	0.28	0.37
Domestic (within the region) working ratio	-	0.89	0.85

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 4.25: Estimation results of main socioeconomic indicators

	2005	2025	2025/2005
Population	1,353,200	3,005,815	2.22
No. of households	317,762	751,454	2.36
GDP (mil RM)	37,641	176,224	4.68
GDP (RM/capita)	27,817	58,628	2.11
Output (mil RM)	121,431	474,129	3.90
Primary industry	1,860	5,375	2.89
Secondary industry	83,502	263,444	3.15
Tertiary industry	36,069	205,309	5.69
Floor space of commercial buildings (mil m^2)	6.8	19.3	2.82
Offices	0.6	1.7	2.93
Shops	5.7	16.3	2.88
Hospitals & schools	0.6	1.2	2.12

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)

	2005		2025				Transport volume change ratio		
	Transport volume	Share	BaU Transport volume	Share	CM Transport volume	Share	BaU/ 2005	CM/ 2005	CM/ BaU
Railways	23	0.01	222	0.03	395	0.07	9.65	17.17	1.78
Bus	65	0.02	987	0.11	1,350	0.22	15.18	20.77	1.37
Motorcar	2,374	0.62	5,431	0.63	2,731	0.45	2.29	1.15	0.50
Motorcycle	1,005	0.26	1,481	0.17	978	0.16	1.47	0.97	0.66
Walk	163	0.04	247	0.03	219	0.04	1.52	1.34	0.89
Bicycle	186	0.05	309	0.04	329	0.05	1.66	1.77	1.06
Total	3,816	1.00	8,677	1.00	6,003	1.00	2.27	1.57	0.69

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

	2005		2025				Transport volume change ratio		
	Transport volume	Share	BaU Transport volume	Share	CM Transport volume	Share	BaU/ 2005	CM/ 2025	CM BaU
Railways	11	0.01	33	0.01	1,073	0.22	3.15	102.14	32.43
Freight vehicle	1,642	0.99	5,171	0.99	3,734	0.78	3.15	2.27	0.72
Total	1,652	1.00	5,204	1.00	4,807	1.00	3.15	2.91	0.92

The output by industry is shown in Table 4.28.

Table 4.28: Output by industry

	Output (mil RM)			Composition ratio		
	2005	2025	2025/2005	2005	2025	2025/2005
Primary industry	1,860	5,375	2.89	0.02	0.01	0.74
Agriculture	1,860	5,375	2.89	0.02	0.01	0.74
Mining	0	0		0.00	0.00	
Secondary industry	83,502	263,444	3.15	0.69	0.56	0.81
Food Products and Beverages	9,228	58,715	6.36	0.08	0.12	1.63
Chemicals and Chemical Products	6,651	37,422	5.63	0.05	0.08	1.44
Electric and Electronic Products and Machinery	26,803	61,826	2.31	0.22	0.13	0.59
Fabricated Metal Products and Machinery	22,032	48,531	2.20	0.18	0.10	0.56
Other Non-Metallic	5,378	24,664	4.59	0.04	0.05	1.17
Rubber and Plastics Products	7,095	18,908	2.66	0.06	0.04	0.68
Construction	6,315	13,378	2.12	0.05	0.03	0.54
Tertiary industry	36,069	205,309	5.69	0.30	0.43	1.46
Transport related	7,226	11,996	1.66	0.06	0.03	0.43
Wholesale and Retail	11,358	58,694	5.17	0.09	0.12	1.32
Tourism and Hospitality	9,261	59,486	6.42	0.08	0.13	1.65
Professional and Business	3,887	48,547	12.49	0.03	0.10	3.20
Medical and Education	1,840	7,783	4.23	0.02	0.02	1.08
Other Services	1,705	17,996	10.56	0.01	0.04	2.70
Public administration	793	807	1.02	0.01	0.00	0.26
Total (mil RM)	121,431	474,129	3.90	1.00	1.00	1.00

4.7.2 Energy demand and CO_2 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

	Coal	Petroleum	Gas	Renewable	Electricity	Total
Residential	0	47	0	0	193	240
Commercial	0	53	2	0	328	382
Industry	50	679	623	0	381	1,733
Passenger transport	0	357	2	0	0	359
Freight transport	0	568	4	0	0	572
Total	50	1,704	632	0	901	3,286

2025BaU

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

2025CM

	Coal	Petroleum	Gas	Renewable	Electricity	Total
Residential	0	16	52	130	452	649
Commercial	0	18	25	49	592	685
Industry	100	346	2,275	0	774	3,494
Passenger transport	0	70	116	65	2	253
Freight transport	0	230	384	213	6	834
Total	100	680	2,852	457	1,825	5,915

Table 4.30: Primary energy demand (ktoe)

	Coal	Petroleum	Gas	Hydro	Renewables	Total
Energy demand						
2005	289	1,729	1,209	60	0	3,286
2025BaU	1,844	4,978	3,854	61	7	10,743
2025CM	1,032	691	3,699	35	457	5,915
Percentage distribution						
2005	9%	53%	37%	2%	0%	100%
2025BaU	17%	46%	36%	1%	0%	100%
2025CM	17%	12%	63%	1%	8%	100%

2) CO_2 emissions

The estimation result of CO_2 emissions is shown in Table 4.31 . CO_2 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 CO_2 emissions increase from 9.3 t-CO_2 (2005) to 15.1 t-CO_2 in the BaU case (2025), and 6.5 t-CO_2 in the CM case in 2025. Therefore, Per capita CO_2 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: CO_2 emissions (kt-CO_2)

Sector	2005	2025 BaU	2025 CM	BaU/2005	CM/2005	CM/BaU
Residential	1,468	7,715	2,972	5.26	2.02	0.39
Commercial	2,419	7,195	3,802	2.97	1.57	0.53
Industry	6,035	24,832	10,897	4.11	1.81	0.44
Passenger transport	1,015	1,672	447	1.65	0.44	0.27
Freight transport	1,615	4,070	1,481	2.52	0.92	0.36
Total	12,552	45,484	19,598	3.62	1.56	0.43

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.

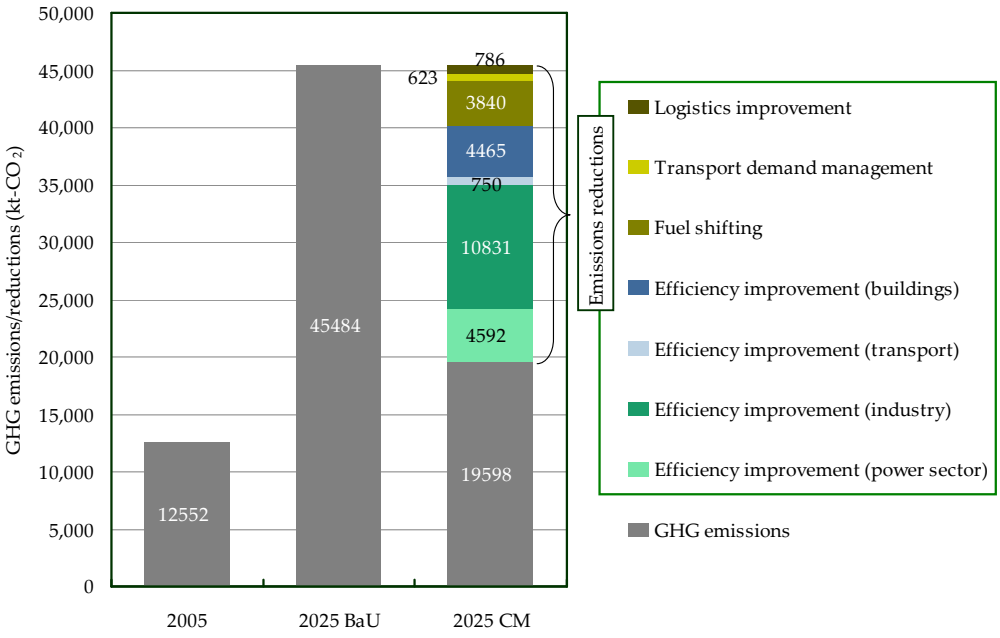

Figure 4.6: Reduction potential by measure type

Table 4.32: List of low-carbon measures

Sector	Low-carbon measures & technologies	Specification		Source	Measure Setting(service type: fuel type)	
Residential	Air conditioner(highest efficiency)	COP	6.60	*2	Diffusion rate (cooling)	100%
	Oil water heater(high efficiency)	COP	0.83	*1	Diffusion rate (hot water: petroleum)	80%
	Gas heater(latent heat recovery)	COP	0.83	*1	Diffusion rate (hot water: gas)	100%
	Heat pump water heater	COP	4.50	*1	Diffusion rate (hot water: electricity)	80%
	Gas stove(high efficienct)	Thermal efficiency (base year =1)	1.22	*1	Diffusion rate (kitchen: gas)	100%
	Electric stove(IH) (high efficient)	Thermal efficiency (base year =1)	1.15	*1	Diffusion rate (kitchen: electricity)	80%
	Efficiency improvement of other electric appliances	Electricity consumption (base year =1)	0.48	*1	Electricity consumption (base year =1)	0.48
	Fluorescent light(Incandescent type)	Electricity consumption (base year =1)	4.35	*1	Diffusion rate (incandescent)	20%
	LED(incandescent light alternative)	Electricity consumption (base year =1)	8.70	*1	Diffusion rate (incandescent)	80%
	Fluorescent light(hf inverter)	Electricity consumption (base year =1)	1.33	*1	Diffusion rate (fluorescent)	40%
	LED(fluorescent light alternative)	Electricity consumption (base year =1)	2.67	*1	Diffusion rate (fluorescent)	25%
	Insulation level improvement of house (next generation standard)	Thermal loss (base year =1)	0.42	*3	Diffusion rate	80%
	Behaviour changes for energy saving			*6		
	Cooling	Reduction rate of energy service demand	20%		Diffusion rate	50%
	Hot water	Reduction rate of energy service demand	20%		Diffusion rate	50%
	Kitchen	Reduction rate of energy service demand	20%		Diffusion rate	50%
	Other home appliances	Reduction rate of energy service demand	20%		Diffusion rate	50%
	Photovoltaic power generation				Introduction amount (ktoe)	21
	Solar water heater				Introduction amount (ktoe)	21
Commercial	Air conditioner cooling dedicated (high efficient)	COP	2.85	*1	Diffusion rate (cooling: electricity)	23%
	Air conditioner cooling dedicated (highest efficiency)	COP	4.07	*1	Diffusion rate (cooling: electricity)	42%
	Air conditioner cooling dedicated (super highest efficient)	COP	5.00	*2	Diffusion rate (cooling: electricity)	25%
	Absorption water cooler & heater (gas) (high efficient)	COP	1.35	*4	Diffusion rate (cooling: gas)	80%
	Oil water heater(high efficient)	COP	0.87	*1	Diffusion rate (hot water: petroleum)	100%
	Gas heater(high efficient)	COP	0.87	*1	Diffusion rate (hot water: gas)	100%
	CO_2 refrigerant water heater	COP	3.00	*1	Diffusion rate (hot water)	25%
	Gas kitichen(high efficienct)	Thermal efficiency (base year =1)	1.15	*1	Diffusion rate (kitchen: gas)	80%
	Electric stove(IH) (high efficient)	Thermal efficiency (base year =1)	1.15	*1	Diffusion rate (kitchen: electricity)	40%
	Efficiency improvement of other electric devices	Electricity consumption (base year =1)	0.41	*1	Electricity consumption (base year =1)	0.41
	LED(incandescent light alternative)	Electricity consumption (base year =1)	4.55	*1	Diffusion rate (incandescent)	50%
	LED(fulorescent light alternative, timer controled)	Electricity consumption (base year =1)	3.95	*1	Diffusion rate (fluorescent)	25%
	High insulation commercial building	Thermal loss (base year =1)	0.60	*1	Diffusion rate	100%
	BEMS	Reduction rate of energy service demand	10%	*5	Diffusion rate	50%
	Behaviour changes for energy saving			*6		
	Cooling	Reduction rate of energy service demand	20%		Diffusion rate	50%
	Photovoltaic power generation				Introduction amount (ktoe)	21
	Solar water heater				Introduction amount (ktoe)	40
Industry	High efficient industrial devices					
	High efficient boiler	Thermal efficiency (base year =1)	1.09	*6	Diffusion rate	100%
	High efficient industrial furnace	Thermal efficiency (base year =1)	1.67	*7	Diffusion rate	100%
	High efficient motor	Electricity consumption (base year =1)	0.95	*6	Diffusion rate	100%
	Inverter controlling	Electricity consumption (base year =1)	0.85	*6	Diffusion rate	100%
	Fuel shift	shift from petroleum to natural gas			Conversion ratio	75%
Passenger transport	Hybrid passenger vehicle	Fuel efficiency (conventional=1)	0.6	*1	Diffusion rate	50%
	Modal shift	from motorcar & motorcycle to others				
		to walk and bicycle			Conversion ratio	3%
		to railway			Conversion ratio	5%
		to bus			Conversion ratio	10%
	Bio-fuel	from petroleum to bio-fuel			Diffusion rate	20%
Freight transport	Modal shift	from freight vehicle to freight railway			Conversion ratio	10%
	Bio-fuel	from petroleum to bio-fuel			Diffusion rate	20%
Transformation	Emission factor improvement				Carbon Intensity (tC/toe)	1.70
	Power generation efficiency improvement					
	Coal fired power generation	Power generation efficiency	48%	*8		
	Natural gas fired power generation	Power generation efficiency	55%	*9		

*1 みずほ情報総研(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章対策シナリオ」.
*2 省エネルギーセンター(2007):省エネ性能カタログ2007年冬.
*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 2003年2月発表: http://www.osakagas.co.jp/Press/pr03/030213.htm
*5 経済産業省(2005): 技術戦略マップ(エネルギー分野) ～超長期エネルギー技術ビジョン～.
*6 滋賀SD2030研究チーム(2005): 滋賀県・持続可能な社会づくり研究プロジェクト報告書.
*7 新エネルギー・産業技術総合開発機構(2005): 高性能工業炉導入フィールドテスト事業成果報告書.
*8 クリーンコールパワー研究所HP : http://www.ccpower.co.jp/
*9 日本経済新聞朝刊, 2008年3月14日.

4.8 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.

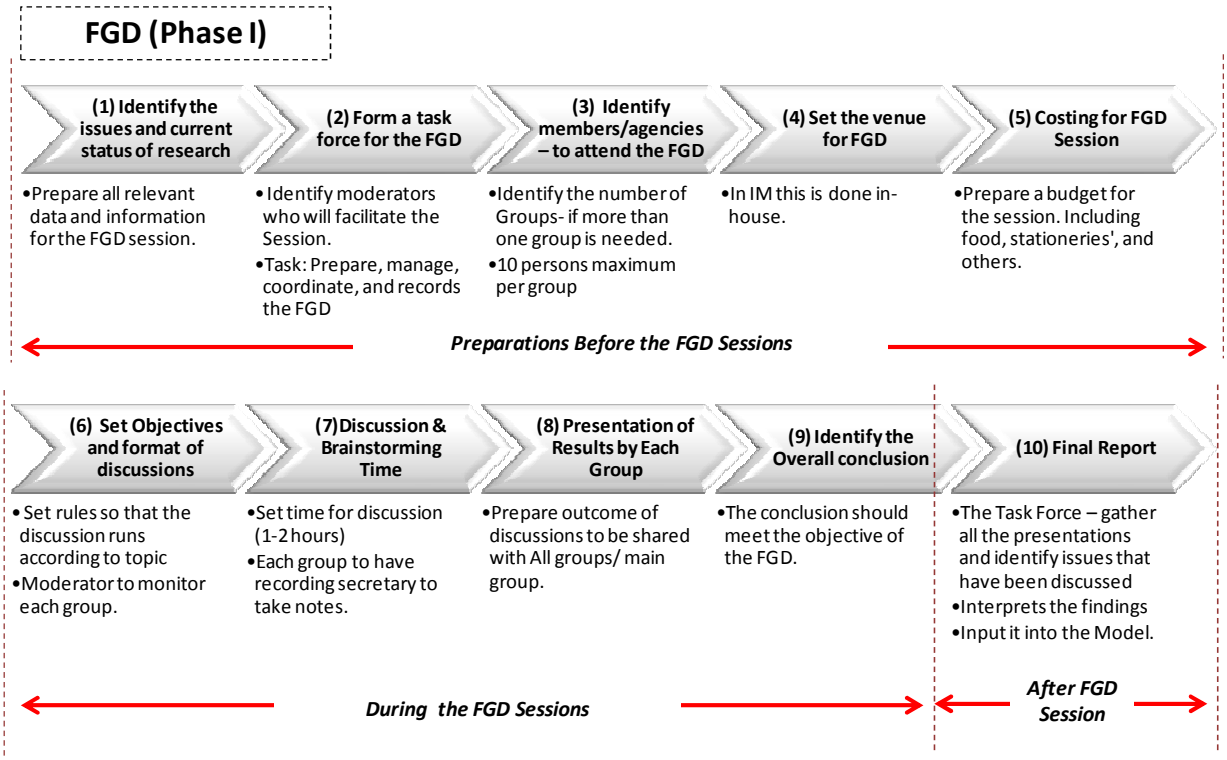

Figure 4.7: Structure of FGD, Phase I in IRDA

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.

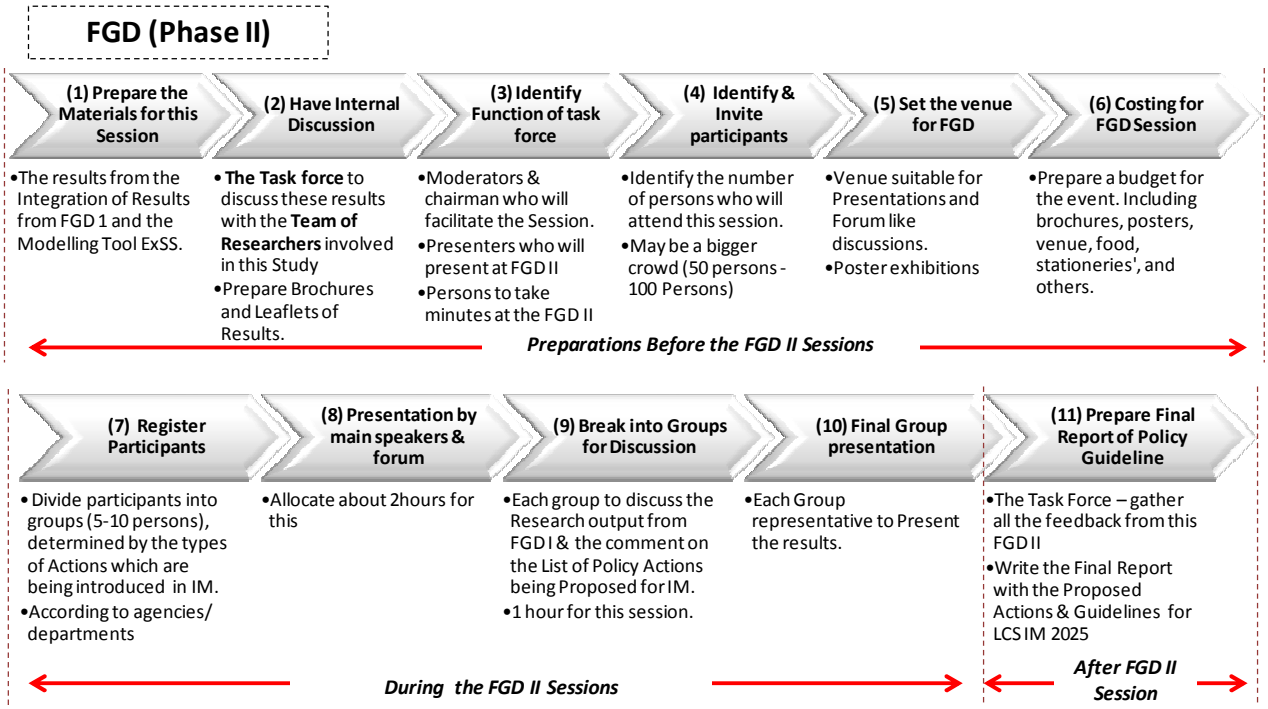

Figure 4.8: Structure of FGD, Phase II in IRDA

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 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 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.

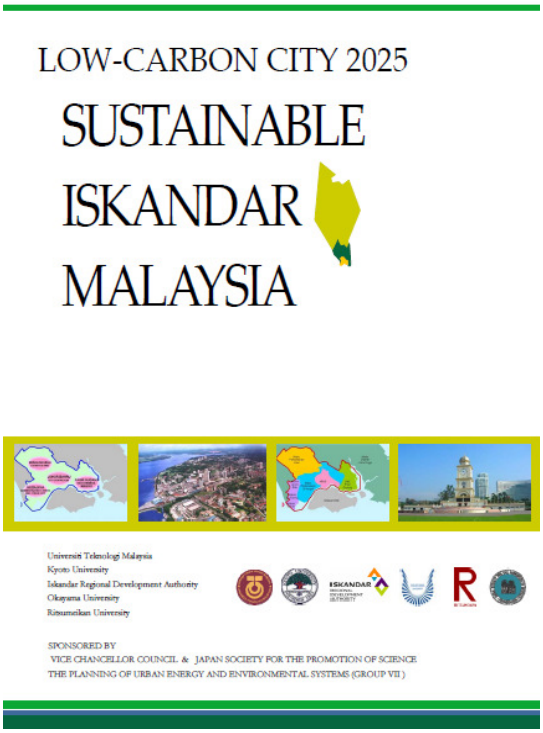

Figure 4.9: Low Carbon City 2025, Sustainable Iskandar Malaysia Brochure

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 5.1: Landuse Components of Putrajaya

Land Use	Hectares	Percentage
Government	225	4.6%
Residential	711	14.4%
Commercial	139	2.8%
Mixed Use	41	0.8%
Special Use	139	2.8%
Service Industry	11	0.2%
Public Amenity	344	7.0%
Open Space	1930	39.2%
Infrastructure & Utility	483	9.8%
Road	908	18.4%
Total	**4,931**	**100**%

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".

Table 5.2: List of Research Team Members

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

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

Name (Task Force)		Affiliation	Position
9	Dr. Kei GOMI	Kyoto University	Research Fellow, Graduate School of Engineering. (GSE)
10	Mr. Azhar bin Othman	Putrajaya Corporation (PJC)	Senior Assistant Director of Planning Department
11	Ms. Wang Tze Wee	Putrajaya Corporation (PJC)	Assistant Director of Planning Department
12	Ms. Maiko SUDA	NIES	Assistant Fellow
13	Dr. Genku KAYO	NIES	Post-doctoral fellow
14	Ms. Janice Jeevamalar Simson	Kyoto University	Ph. D candidate, (GCE)
15	Ms. Siti Norbaizura	Okayama University	Graduate Student, Graduate School of Environmental Science
16	Ms. Yuri HAYASHI	Kyoto University	Undergraduate Student, (GCE)
17	Mr. Tomohito HAMADA	Okayama University	Undergraduate Student, Graduate School of Environmental Science

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).

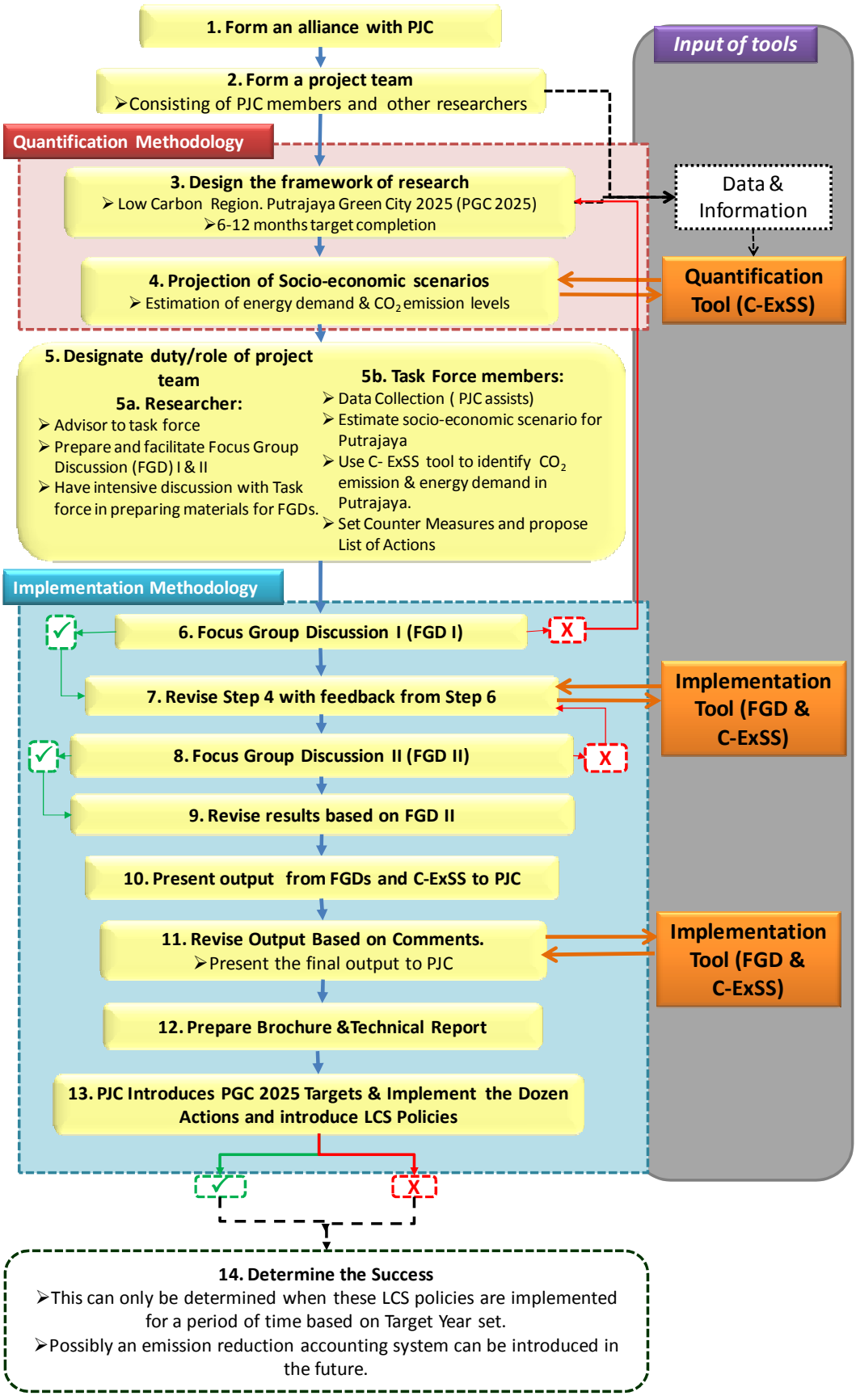

Figure 5.1: Methodology of Implementing a Low Carbon Scenario in Putrajaya

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 CO_2 emission intensity (CO_2 emission per economic activity) by 60% compared to the levels in 2007. To achieve this, the current and future levels of CO_2 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.

Socio-economic indicators	Assumption
Population	347,700 persons in year 2025.
Household	79,023 households in year 2025.
In-coming persons	67,947 persons per day in year 2025.
Out-going persons	47,672 persons per day in year 2025.
Floor area	17,229,100 m^2 in year 2025. (4.5 times compared to 2007 level)
Employment	164,500 employees in year 2025. (3.7 times compared to 2007 level)
Economy in Malaysia	Per capita GDP will grow approximately an average of 4.3% per year.
Passenger transport generation	It is assumed not to change from year2007 to 2025 because following factors will cause increase and decrease; [Factor in increase] Increase in leisure & recreation time [Factor in decrease] Aging society, IT society
Modal share of passenger transport trip	Modal share will shift from "Bicycle, Walk""Motorcycle" to "Automobile" because of economic growth.
Average trip distance	Trip distance of bicycle and walk will decrease because of modal shift to Automobile.
Freight transport demand	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.
Energy service demand	Per floor area or per capita energy service demand will increase by 1 to 2.13 times.

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 21times 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.

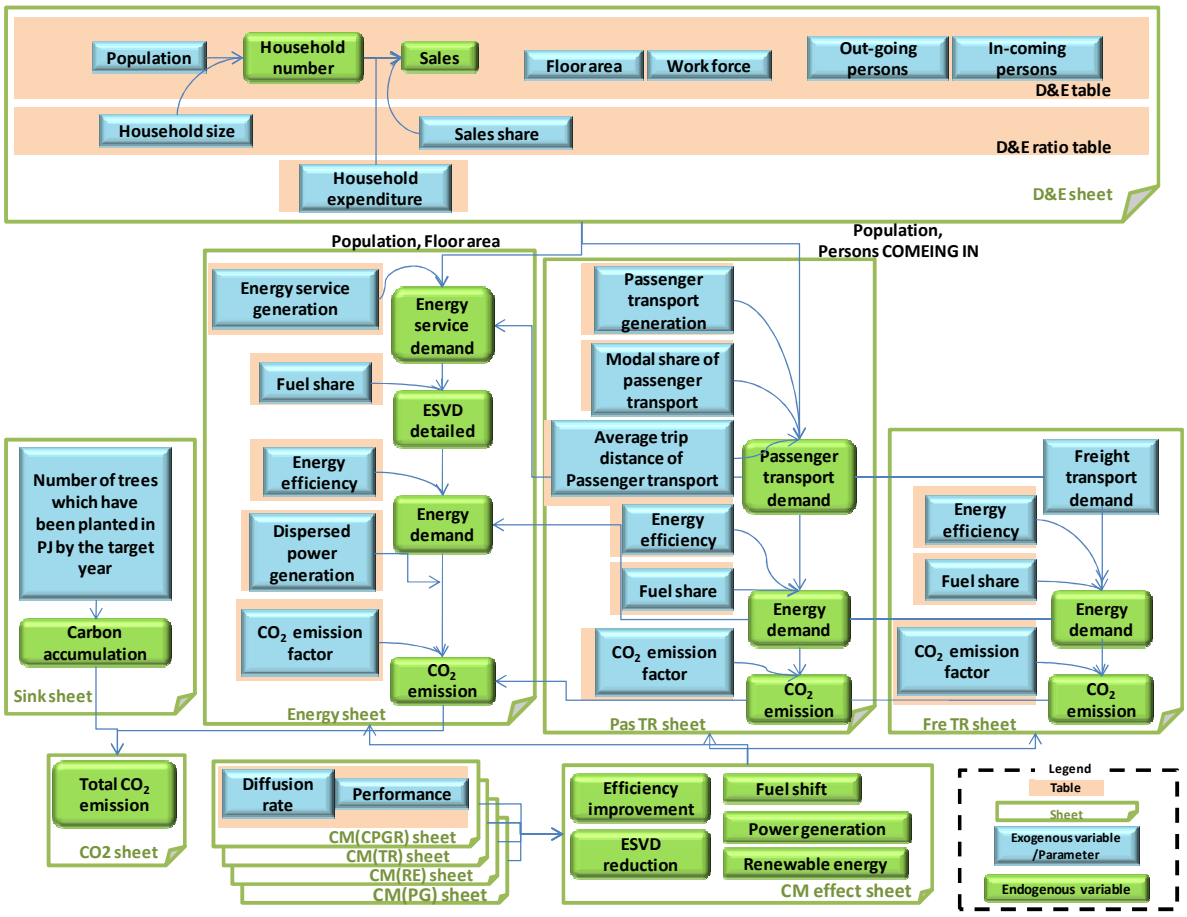

Figure 5.2: Structure of C-ExSS

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 CO_2 emissions in the base year is calculated. The third step is when the CO_2 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.

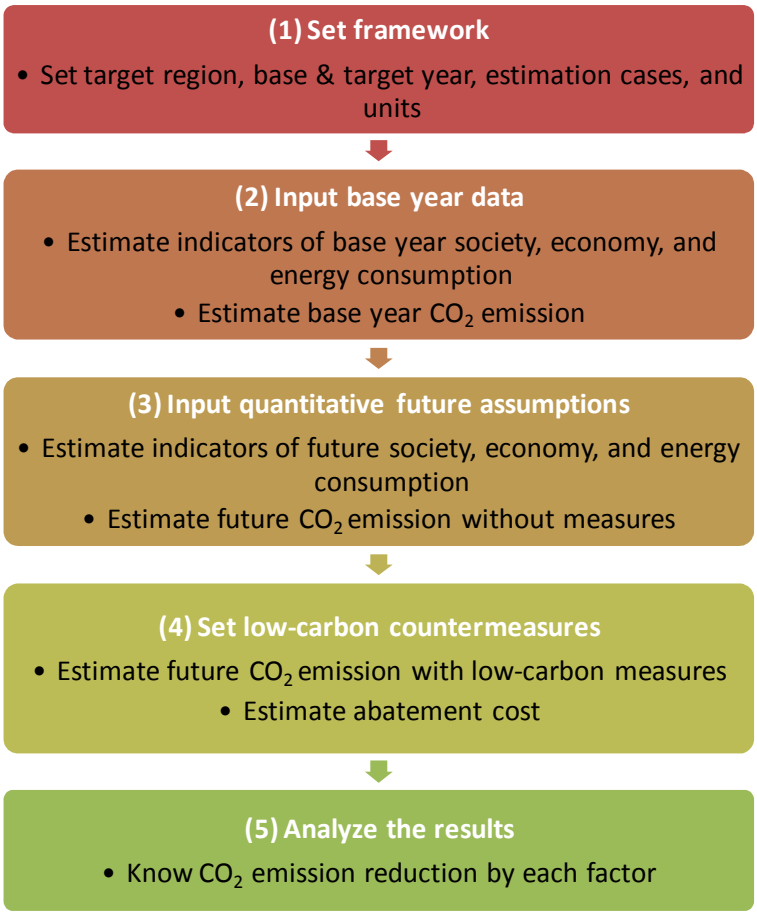

Figure 5.3: The Calculation Procedure in C-ExSS

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

Sector	Classification	Sector	Classification
Commertial	Office/Commercial complex	Government departments	Parcel A - PM's office
	Shop/Shop office		Parcel B - Prime Minister's Department
	Hotel		Parcel C - Ministry Of Science, Technology & Inovations & Other Agencies
	Shopping mall		Parcel D
	Restaurant		Parcel E
	Mix development (housing + commercial)		Parcel F
	Petroleum station		2G1 - Ministry of Finance
	Service industry		2G2 - Perbendaharaan & Kastam
	Private amenities		2C1 - Ministry of the federal territory and welfare of town
			2G3 - Ministry Of Dosmetic Trade and Cosumers Affair
Public amenities & facilities	Public kindergarten		2G4 - Ministry Of PlantationsIndustries and Commodoties
	School		2G5 - National Registration Department
	Hospital/Clinic		2G6 - Ministry Of Entrepreneur and Co-operative Development (MEDC)
	Mosque/Small mosque		2G7 - Foreign ministry
	Fire Department		2G8 - Housing loan department
	Police station		2C15 - Energy commission
	Neighbourhood Complex		2C10 - Election commission
	Food Court (landed)		3G1 - Department of Judiciary & Law Affairs
	City service center		3G2 - Putrajaya Corporation
	Recycle center		3G3 - Palace Of Justice
	Market		3M2+C2+C3 - Pilgrimage fund boad complex
	Utility		4G1 - Ministry Of Agriculture and Agro - Based Industries)
			4G2 - Fisheries Department
Residential	High income		4G3 - Ministry Of Natural Resources and Environment
	Middle income		4G4 - Ministry Of Youths and Sports
	Low income		4G5 - Ministry of road transportation
			4G7 - Attorney General's Chamber
			4G8 - Ministry of rural and regional development
			4G9 - Ministry of information, communication, arts, and culture
			4G10 - Ministry of housing and local government
			4G11 - Ministry of women, family, and community development
			5G2 - Ministry of higher education, and Ministry of tourism
			Other government building

2) Target Services

The following activities were considered as energy demanding services; using "Cooling", "Hot water", "Cooking", "Lighting", "Other electric appliances (TV, Refrigerator, Elevator, Vending machine, etc.)", and "Passenger transport", "Freight transport".

3) Low-carbon target

The low-carbon target is to reduce CO_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_2 emission factor, we can gain energy demand and CO_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 …..

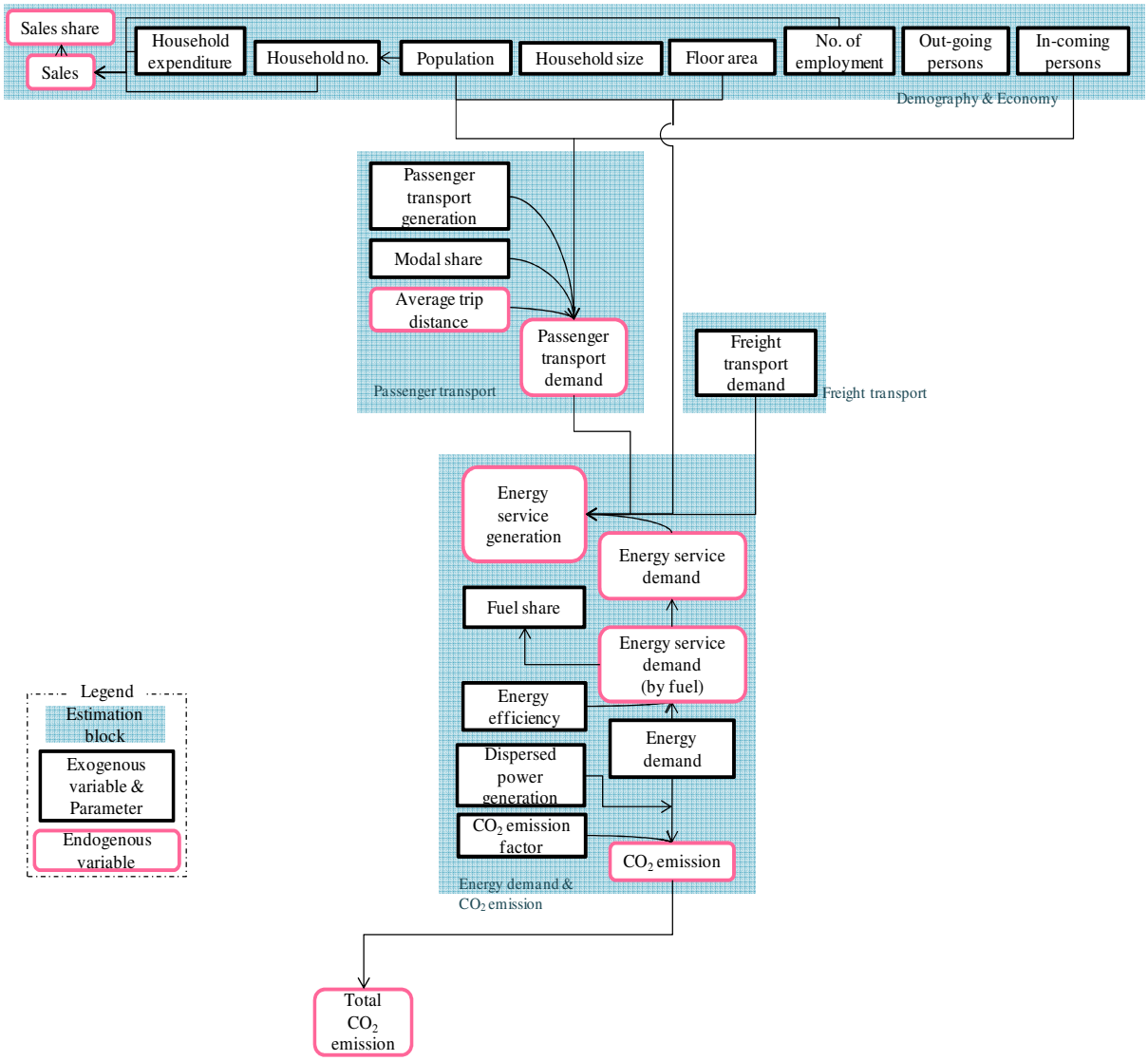

Figure 5.4: Calculation flow for C-ExSS in Base year

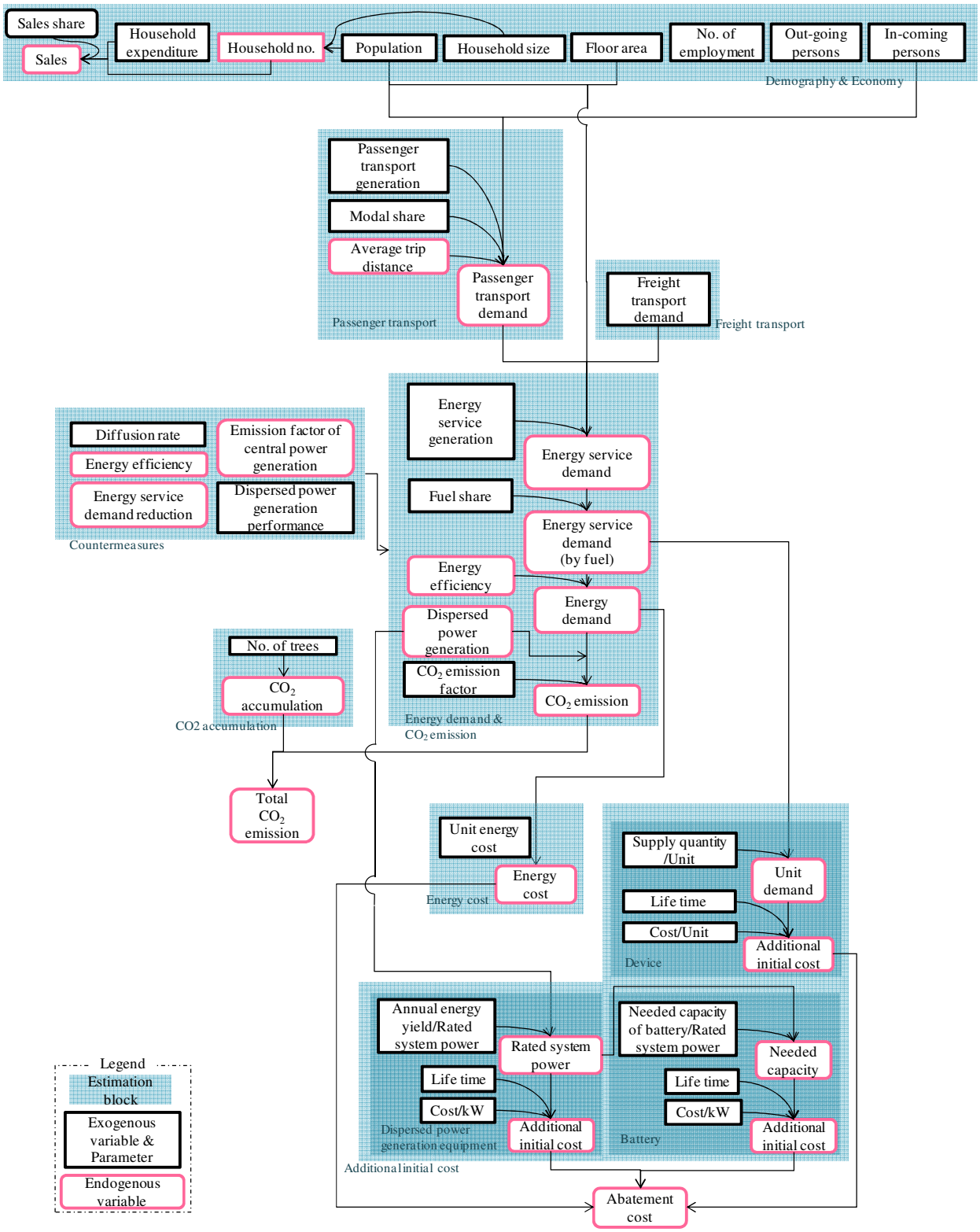

Figure 5.5: Calculation flow for C-ExSS in target year

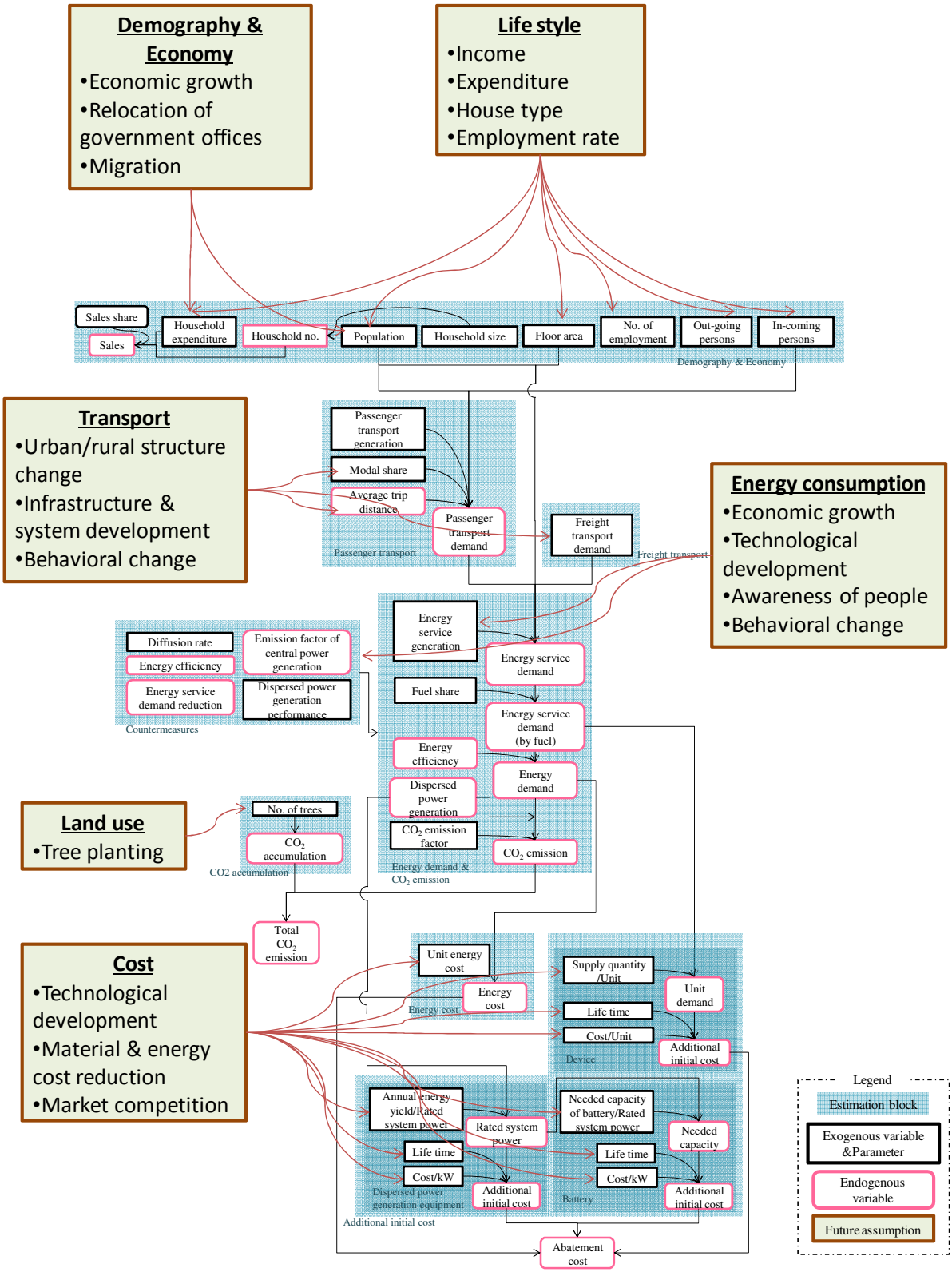

Figure 5.6: Assumption for future scenario calculation in C-ExSS

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 (4.4person/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 m^2 (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.

Table 5.6: Estimation results of the socio-economic indicators

	2007	2025BaU	2025CM	2025BaU /2007
Population[no.]	49,452	347,700	347,700	7.03
Employment[no.]	45,000	164,500	164,500	3.66
Per capita GDP in Malaysia [Mill.RM]	23,605	50,337	50,337	2.13
Economic activity (2007=1)	1	7.8	7.8	7.80
Passenger transport demand [Mill.pass-km]	585	4,230	3,719	7.23
Freight transport demand [Mill.t-km]	109	851	681	7.80
Final energy demand[ktoe]	135	908	411	6.70
Final energy demand per economic activity (2007=1)	1	0.86	0.39	0.86
Primary energy demand[ktoe]	1,339	10,092	5,277	7.53
CO_2 emission[ktCO_2]	516	3,772	1,591	7.31
CO_2 emission per economic activity (2007=1)	1	0.9	0.4	0.94

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 5.7: Estimation result of passenger transport demand

	2007		**2025BaU**		**2025CM**		**2025 BaU /2007**	**2025 CM /2007**	**2025 CM/ 2025 BaU**
	[Mill.pass-km/year]	[%]	[Mill.pass-km/year]	[%]	[Mill.pass-km/year]	[%]			
Bicycle,Walk	35	6	97	2	148	4	2.79	4.27	1.53
Motorcycle	158	27	998	24	551	15	6.32	3.49	0.55
Automobile	297	51	2495	59	1,048	28	8.40	3.53	0.42
Bus	59	10	398	9	453	12	6.72	7.65	1.14
Rail	36	6	242	6	1,518	41	6.72	42.15	6.27
Total	**585**	**100**	**4230**	**100**	**3,719**	**100**	**7.23**	**6.36**	**0.88**

Table 5.8: Estimation result of freight transport demand

	2007	2025BaU	2025CM	2025BaU /2007	2025CM /2007	2025CM/ 2025BaU
Freight transport demand[Mill.t-km/year]	109	851	681	7.80	6.24	0.80

2) Energy demand and CO_2 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

	2007	2025BaU	2025CM	2025BaU /2007	2025CM/ 2007	2025CM/ 2025BaU
Commercial	10.11	222.04	151.82	21.95	15.01	0.68
Public amenities & facilities	10.47	37.25	22.02	3.56	2.10	0.59
Government departments	46.26	82.17	44.97	1.78	0.97	0.55
Residential	4.43	46.57	32.61	10.51	7.36	0.70
Passenger transport	57.07	464.46	128.11	8.14	2.24	0.28
Freight transport	7.06	55.06	31.65	7.80	4.48	0.57
Total	**135**	**908**	**411**	**6.70**	**3.04**	**0.45**

Table 5.10: Estimation results of primary energy demand

[ktoe]	2007	2025BaU	2025CM	2025BaU /2007	2025CM /2007	2025CM/ 2025BaU
	1,339	10,092	5,277	7.5	3.9	0.5

ii. *CO_2 emissions*

The estimation results of CO_2 emissions are shown in Table 5.11 and those of CO_2 emission per economic activity are shown in Table 5.12. CO_2 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.

CO_2 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 CO_2 emission per economic activity is reduced 60% compared to 2007.

Table 5.11: Estimation results of CO_2 emissions

	2007	2025BaU	2025CM	2025BaU /2007	2025CM/ 2007	2025CM/ 2025BaU
Commercial	65	1435	769	22.23	11.92	0.54
Public amenities & facilities	67	240	112	3.60	1.68	0.47
Government departments	180	363	139	2.01	0.77	0.38
Residential	23	266	150	11.40	6.42	0.56
Passenger transport	161	1314	368	8.14	2.28	0.28
Freight transport	20	156	89	7.80	4.45	0.57
Carbon sink (Tree planting)	-	-	-35	-	-	-
Total	**516**	**3772**	**1591**	**7.31**	**3.08**	**0.42**

Table 5.12: Estimation results of CO_2 emission per economic activity (year 2007=1)

	2007	2025BaU	2025CM	2025BaU /2007	2025CM/ 2007	2025CM/ 2025BaU
CO_2 emission per economic activity emission (2007=1)	1	0.94	0.40	0.94	0.40	0.42

3) Low-carbon countermeasures

It shows that countermeasures for passenger transport contribute to CO_2 emission reduction the most (939ktCO_2), and second largest contributor is those for commercial sector (452ktCO_2). Please see also Appendix 7.11~7.15 for the list of introduced low-carbon measures with their performance, diffusion rate, CO_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.

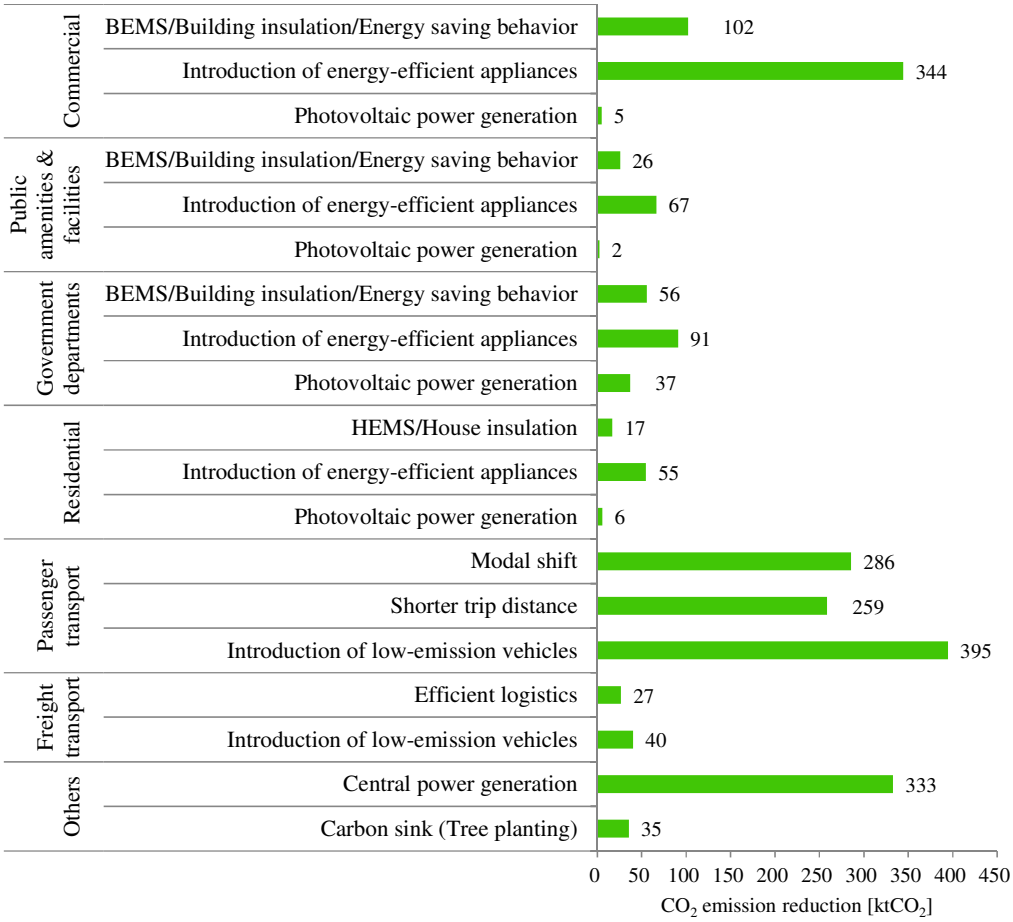

Figure 5.7: CO_2 emission reduction by countermeasure types

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 CO_2 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_2 emission reduction contribution

Below listed are the Action, sub-actions and the amount of CO_2 emission reduction each sub action contributes towards the overall CO_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

CO_2 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 5.13: CO_2 emission reduction by Action1

	Sub-action	Methodology of allocating emission reduction	CO_2 emission reduction [$ktCO_2$]	Contri-bution in the Action [%]	Contri-bution in total reduction [%]
1-1	**Make cycling as preferred transport option (Bikeable City)**	Contribution of "(24)Pedestrian-friendly city development" in 90% of reduction by	53	17%	2%
1-2	**Make walking as preferred transport option (Walkable City)**				
1-3	**Enhance mixed-use and diversified development**	Contribution of "Shorter trip distance" ((26)Introduction of new rail line, (27)Mixed use development, (28)ITS)	259	83%	11%
1-4	**Residential Layout Planning**				
1-5	**Introduce Low Carbon Planning Control & Development Plans & Practices**				
1-6	**Allocate Land for Soild Waste Management Facilities. Management Plan**	-	-	-	-
	Total		**312**	**100%**	**13%**

2) Action 2

CO_2 emission reduction by Action2 “Low-carbon Transportation” and corresponding countermeasures are shown in Table 5.14. In this action, CO_2 emission is reduced by efficiency improvement of vehicle and modal shift to public transportation.

Table 5.14: CO_2 emission reduction by Action 2

	Sub-action	Methodology of allocating emission reduction	CO_2 emission reduction [$ktCO_2$]	Contri-bution in the Action [%]	Contri-bution in total reduction [%]
2-1	**Encourage the Use of Low-carbon emission vehicles**	It is assumed that 90% of emission reduction by "Efficiency improvement of motorcycles, automobiles, buses"is lead by Efficiency improvement of vehicles and 10% is by ITS. So emission reduction of this sub-astion is; (90% of Contribution of "(17)High efficiency internal combustion vehicle""(18)Hybrid vehicle""(19)Electric vehicle""(20)High efficiency natural gas vehicle""(21)High efficiency natural gas bus"in "Efficiency improvement of motorcycles, automobiles, buses") +(Contribution of "(16)High efficiency motorcycle""(22)Efficiency improvement of trains" in "Efficiency improvement of motorcycles, automobiles, buses")	362	62%	15%
2-2	**Implement Integrated Transportation System**	It is assumed that 90% of emission reduction by "Efficiency improvement of motorcycles, automobiles, buses"is lead by Efficiency improvement of vehicles and 10% is by ITS. So emission reduction of this sub-astion is; (10% of Contribution of "(17)High efficiency internal combustion vehicle""(18)Hybrid vehicle""(19)Electric vehicle""(20)High efficiency natural gas vehicle""(21)High efficiency natural gas bus"in "Efficiency improvement of motorcycles, automobiles, buses") +(10% of "Modal shift")	61	11%	3%
2-3	**Implement Intelligent Transportation System**				
2-4	**Encourage Transit Oriented Development (TOD)**				
2-5	**Increase Public Transport Provision & Usage**	(90% of contribusion of "(25)Introduction of new rail line""(23)Enhancement of bus system" in "Modal shift") +(Contribution of "(25)Introduction of new rail line" in "Shorter trip distance")	159	27%	7%
	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 5.15: CO_2 emission reduction by Action3

	Sub-action	Methodology of allocating emission reduction	CO_2 emission reduction [$ktCO_2$]	Contri-bution in the Action [%]	Contri-bution in total reduction [%]
3-1	**Eco friendly Building Materials & Energy Efficient Labeling for Equipments & Appliances.**	Efficiency improvement & fuel shift of "Cooling", "Hot water", "Cooking", "Lighting", and "Other electriappliances"((1)~(7)) in Commercial, Public amenities & facilities, and Government departments sector.	501	75%	21%
3-2	**Building Energy Management System (BEMS)***	Contribution of "(8)BEMS""(10)Energy saving behavior" in Commercial, Public amenities & facilities, and Government departments sector.	115	17%	5%
3-3	**Eco friendly Building Materials**	Contribution of "(9)Building insulation" in Commercial, Public amenities & facilities, and Government departments sector.	50	7%	2%
3-4	**To integrate Recycling facilities in building designs.**	-	-	-	-
3-5	**Impose Building Rating System to all Buildings**	-	-	-	-
	Total		**666**	**100%**	**28%**

* 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_2 emission reduction by Action4

	Sub-action	Methodology of allocating emission reduction	CO_2 emission reduction [$ktCO_2$]	Contri-bution in the Action [%]	Contri-bution in total reduction [%]
4-1	**Energy Efficient Appliences in Homes.**	Efficiency improvement & fuel shift of "Cooling", "Hot water", "Cooking", "Lighting", and "Other electriappliances"((1)~(7)) in Residential sector.	55	77%	2%
4-2	**HEMS (Home Energy Management System)***	Contribution of "(14)HEMS""(10)Energy saving behavior""(15)House insulation" in Residential sector	16	23%	1%
4-3	**Promoting organic / low carbon products**	-	-	-	-
4-4	**To integrate Recycling facilities in High rise residential building designs.**	-	-	-	-
	Total		**71**	**100%**	**3%**

* CO_2 emission reduction by this Sub-action includes the effect of energy saving behavior.

5) Action 5

CO_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_2 emission reduction by Action5

	Sub-action	Methodology of allocating emission reduction	CO_2 emission reduction [$ktCO_2$]	Contri-bution in the Action [%]	Contri-bution in total reduction [%]
5-1	**Photovoltaic power generation and utilisation**	Contribution of "(12)Photovoltaic power generation"	50	100%	2%
5-2	**Alternative fuel source from Solar assisted power generation**	-	-	-	-
5-3	**Explore possibilities of utilizing Solar Thermal**	-	-	-	-
5-4	**Biomass production & utilisation**	-	-	-	-
5-5	**Research & Development for RE for Local consumption**	-	-	-	-
	Total		**50**	**100%**	**2%**

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 5.18: CO_2 emission reduction by Action6

	Sub-action	Methodology of allocating emission reduction	CO_2 emission reduction [$ktCO_2$]	Contri-bution in the Action [%]	Contri-bution in total reduction [%]
6-1	**To develop an Action Plan for urban reforestration**	Contribution of "(33)Carbon sink (Tree planting)"	35	100%	1%
6-2	**To ensure connectivity between fragmented forests**	-	-	-	-
6-3	**To encourage Greenfrastructure Management in City Planning practices.**	-	-	-	-
6-4	**To develop a detailed Tree Inventory Database.**	-	-	-	-
6-5	**Innovation and Research & Development**	-	-	-	-
	Total		**35**	**100%**	**1%**

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

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.

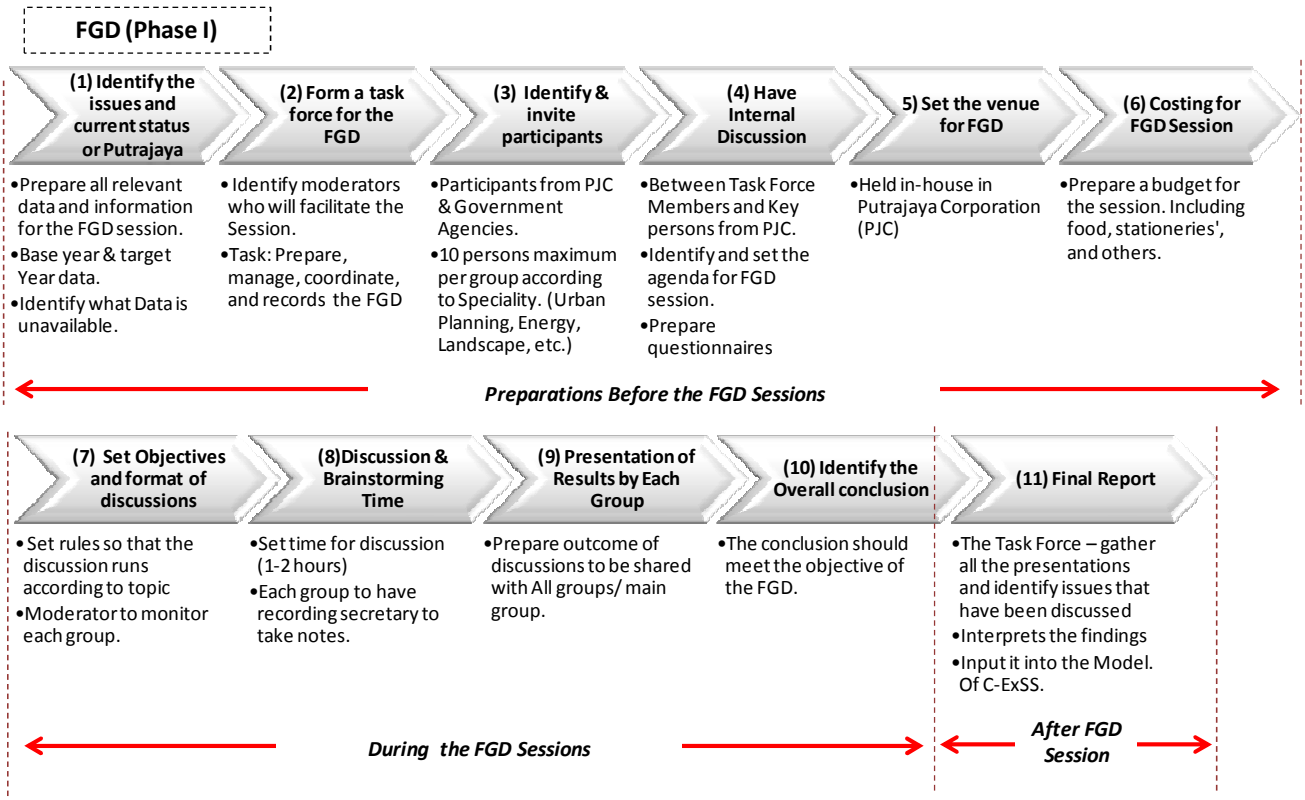

Figure 5.8: Structure of Focus Group Discussion I (FGD I) for PGC 2025

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.

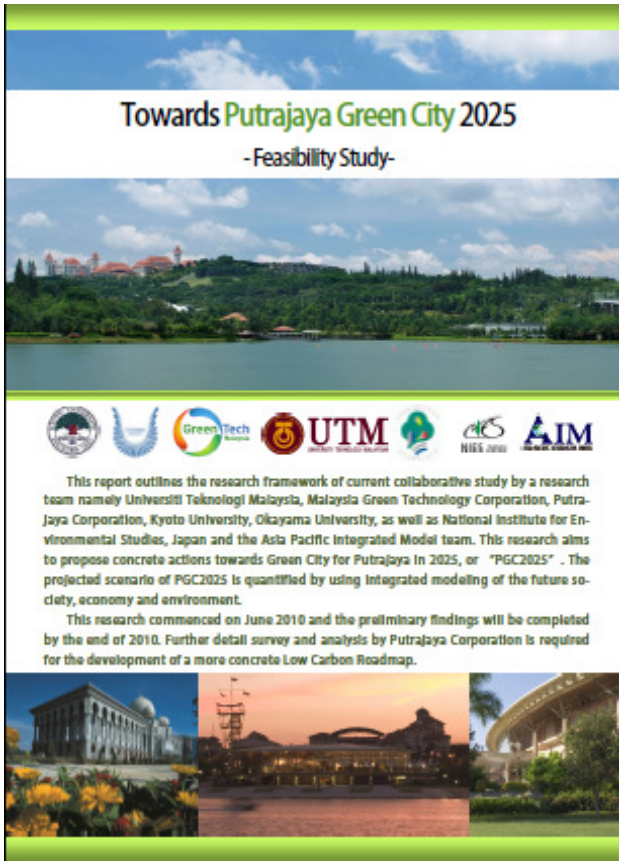

Figure 5.9: The PGC 2025 Leaflet

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.

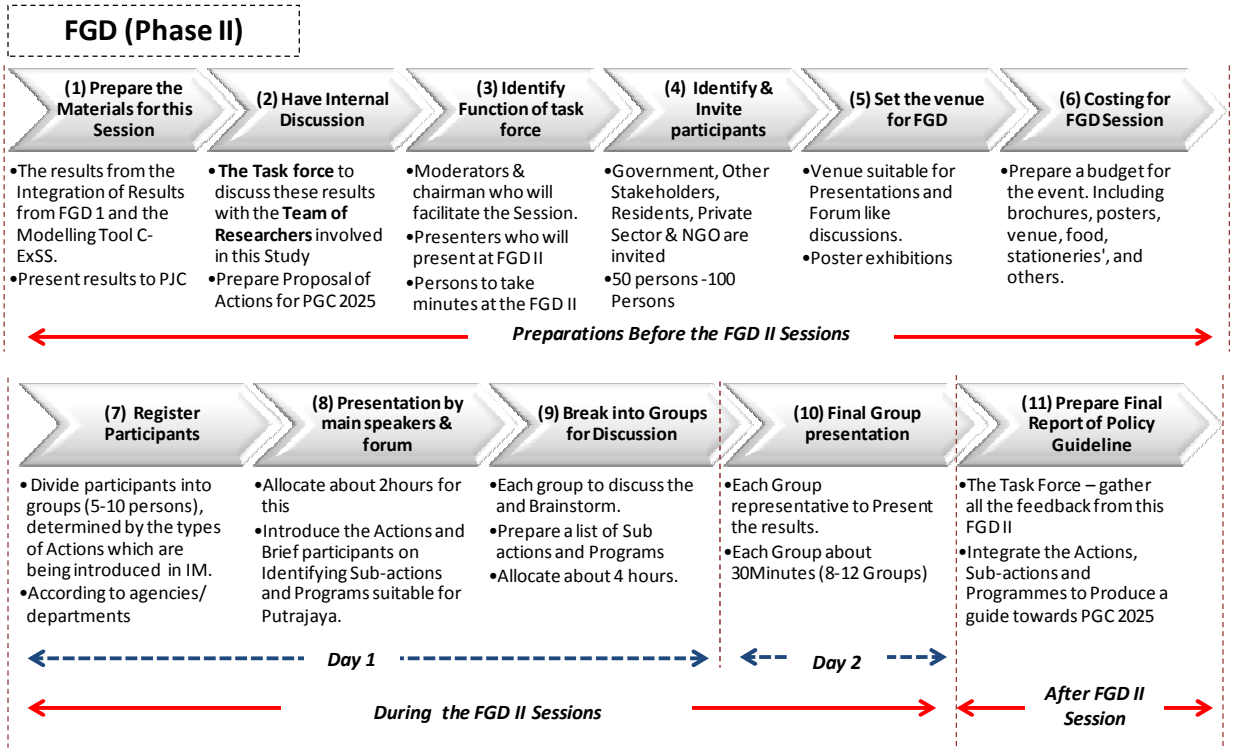

Figure 5.10: Structure of Focus Group Discussion II (FGD II) in for PGC 2025

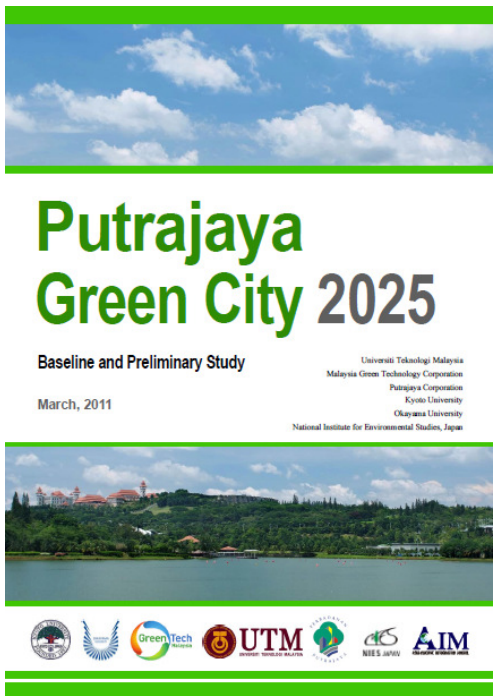

Figure 5.11: The Brochure introducing the Findings from the PGC 2025 Research

5.9 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 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.

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

A, K. R. (1988). *Focus Groups: A practical guide for applied research.* California, USA: Sage Publications. Inc.

Adams, W. M. (2009). *Green Development. Environment and sustainability in a developing world* (3rd Edition ed.). New York: Routledge.

Bruton, M. J. (2007). *Malaysia The Planning of a Nation.* Kuala Lumpur: PERSADA .

Chua, C. S., & Oh, H. T. (2010). Review on Malaysia's national energydevelopments: Key Poliies, agencies, programmes and International Involvements. *Renewable and Sustainable Energy Reviews 14* , 2916-2925.

Delay, T. (2006). *Low Carbon Economy.* London: The Carbon Thrust.

Dept.of Statistics Malaysia. (2010). *Input-Output Tables, Malaysia 2005.* Putrajaya: Department of Statistics, Malaysia.

Economic Planning Unit . (2010a). *Tenth Malaysian Plan 2011-2015.* Putrajaya: PNMB.

Economic Planning Unit. (2006). *Ninth Malaysian Plan 2006-2010.* Putrajaya: EPU.

Escalda, M., & Hong, K. (2007). *Focus Group Discussion.*

Federal Department of Town & Country Planning. (2010). *National Physical Plan 2.* Kuala Lumpur: Ministry of Housing & Local Government.

Federal Dept. of Town & Country Planning. (2009). *A Guide for Conductiong Focus Group Discussions, Charrettes and Village Appraisals.* Kuala Lumpur: JPBD.

Federal Dept. of Town & Country Planning. (2006). *National Urbanization Plan.* Kuala Lumpur: JPBD.

GL, O., & Yuen, B. (2010). *World Cities- Achieving Livability and Vibrancy.* Singapore: World Scientific Co. Pte.Ltd.

Gomi, K., Ochi, Y., & Matsuoka, Y. (2011). A systematic quantitative backcasting on low-carbon society policy in case of Kyoto City. *Technological Forecasting & Social Change* .

Gomi, K., Shimada, K., & Yuzuru, M. (2010). A Low-carbon Scenario Creation Method for a Local-scale Economy and its application in Kyoto City. *Energy Policy* , 4783-4796.

Hu, Y., Peng, Z., & Dequn, Z. (2011). What is low-carbon development? A conceptual analysis. *Energy Procedia* , 1706-1712.

IPCC. (2001). *Climate Change 2001: Impacts, Adaptions and Vulnerability, Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change.* New York, NY: Cambridge University Press.

IPCC. (2007b). *Climate Change 2007: Impacts, adaptation and vulnerability* (Contribution of Working Groups II to the Forthd Assessment Report of the Intergovernmental Panel on Climate Change ed.). (M. L. Parry, O. Canziani, J. Palutikof, V. d. Linden, & C. E. Hanson, Eds.) Cambridge & New York: Cambridge University Press.

IPCC. (2007a). *Climate Change 2007: Mitigation of Climater change.* (O. Davidson, P. Bosch, R. Dave, L. Meyer, & B. Metz, Eds.) Cambridge and New York: Cambridge University Press.

IPCC. (2007). *Climate Change 2007: Syntesis report* (Contribution of Working Groups I, II, and III to the Forthd Assessment Report of the Intergovernmental Panel on Climate Change ed.). (R. K. Pachauri, & A. Reisinger, Eds.) Cambridge & New York: Cambridge University Press.

Johor Department of Town & Country Planning. (2003). *Johore Structure Plan 2001-2020.* Johor Bahru: JPBD.

Kawase, R., Matsuoka, Y., & Fujino, J. (2006). Decomposition analysis of CO2 emission in long-term climate stabilization scenarios. *Energy Policy , 34*, 2113-2122.

Khazanah National. (2006). *Comprehensive Development Plan for South Johor Economic Region 2006-2025.* Kuala Lumpur: Khazanah National.

Lehmann, S. (2010). *The Principles of Green Urbanism.* London: Earthscan.

Lindsey, G., Joel, T. A., & Sheila, H. J. *A Handbook for planning and Conductiong Charrettes for high-preformance projects.* National Renewable Energy Labrotory U.S.

Malaysian Green Technology Corporation (MGTC). (2010). *National Energy Balance Table 2009.* Putrajaya: Ministry of Energy, Green Technology & Water, Malaysia (KeTTHA).

Ministry of Energy, Green Technology & Water. (2009). *National Green Technology Policy.* Putrajaya: KeTTHA.

Ministry of Natural Resource & Environment Malaysia. (2011). *Malaysia, Second National Communication to the UNFCCC.* Putrajaya: NRE Malaysia.

Ministry of Natural Resource & Environment Malaysia. (2009). *National Policy on Climate Change.* Putrajaya: NRE Malaysia.

MOE, Japan. (n.d.). *Ministry of Environment, Government of Japan*. Retrieved 10 20, 2011, from Building a Low Carbon Society: http://www.env.go.jp/en/earth/

Munasinghe, M., & Swart, R. (2005). *Primer on Climate Change & Sustainable Development. Facts, Policy Analysis & Applications.* Cambridge: Cambridge Univesity Press.

National Economic Advisory Council. (2010). *New Economic Model for Malaysia.* Putrajaya: Pencetak Nasional Malaysia Bhd. (PNMB).

New Horizons in Regional Science. (2006). *Regional Climate Change and Variability. Impacts and Responses.* (R. Matthias, D. Kieran, & K. Paul, Eds.) Cheltenham U.K & Massachusettes USA: Edward Elgar Publishing Limited.

PEMANDU. (2010). *Government Transformation Plan.* Kuala Lumpur: Pencetakan Nasional Malaysa Bhd.

Perbadanan Putrajaya (PJC). (2010). *Laporan Pemeriksaan Putrajaya 2009.* Putrajaya: PJC.

Project Management Institute, Inc. (2008). *A Guide to the Project Management Body of Knowledge- Fourth Edition.* Pennsylvania, USA: Project Management Institute, Inc.

Ravetz, J. (2001). *City-Region 2020.* London: Earthscan Publication.

Robert, G. B., Selma, H., Susan, H., James, T., & Graham, W. (2005). *Sustainability Assessment, Criteria and Processes.* London: Earthscan.

Simon, B., & Stephan, M. (2008). *Sustainability Indicators, Measuring the Immeasurable?* London: Earthscan.

Simson, J. J., Ho, S. C., Matsuoka, Y., & Gomi, K. (2011a). Planning Sustainable Development in Malaysia by Incorporating the Concept of Low Carbon Society. *11th International Congress of Asian Planning Schools Association 2011.* Tokyo: APSA.

Simson, J. J., Ho, S. C., Matsuoka, Y., & Gomi, K. (2011). Roadmap of Low Carbon City Development in Malaysia- The Iskandar Malaysia Regional Development Experience. *3rd World Planning Schools Congress* (pp. 1-14, Track 20). Perth: WPSC .

Simson, J., Ho, S. C., Matsuoka, Y., & Gomi, K. (2010). Development of Low Carbon City in Malaysia.- The Case of development corridor of Iskandar Malaysia. *First International Conference on SUstainable Urbanization (ICSU 2010)* (pp. 1-12). Hong Kong : Hong Kong Polytechnic University.

Simson, J., Ho, S. C., Matsuoka, Y., & Gomi, K. (2011b). Low Carnon Urban Development Strategy in Malaysia. The Case of Iskandar Malaysia Development Corridor. *Habitat International- A Journal for the Study of Human Settlements* .

Skea, J., & Nishioka, S. (2008). Policies and practices for a low-carbon society. *Climate Policy* .

Smith, P. F. (2010). *Building for a Changing Climate, The Challenge for Construction, Planning & Energy.* London: Earthscan.

Soderholm, P., Hildingsson, R., Johansson, B., Khan, J., & Wilhelmsson, F. (2011). Governing the transition to low-carbon futures:A critical survey of energy scenarios for 2050. *Futures* , 1105-1116.

UN . (2010). *World Urbanization Prospects: 2009 Revision*. Retrieved November 25, 2011, from http://esa.un.org/unpd/wup/Documents/WUP2009_Highlights_Final.pdf

UN Habitat. (2011). *Cities & Climate Change; Global Report on Human Settlement 2011.* London: Earthscan.

V.R, S. (2011). Sustaining Cities with Climate Change. In B. Yuen, & G. Ooi, *World Cities-Achieving Livability and Vibrancy.* (p. Chapter 11). Singapore: World Scientific Pulblishing Co Pte. Ltd, Singapore.

Whitmarsh, L., Gill, S., & Saffron, O. (2011). Public engagement with carbon and climate change: To what extent is the public 'carbon capable'? *Global Environment Change , 21*, 56-65.

Yoshimoto, K. (2010). *A Study on Quantitative Design of Low-Carbon Societies in Malaysia.* Kyoto: Kyoto University.

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-- George Bernard Shaw

APPENDIX

Appendix 1: List of socioeconomic indicators used for this study (1/2)

Code in ExSS	Name	Value	Unit	Source
POP	Population by age and sex		person	Khazanah Nasional (2006)
	Male			Department of Statistics, Malaysia (2006b)
	0-14	208,547		
	15-64	454,017		
	65+	21,197		
	Female			
	0-14	204,179		
	15-64	444,507		
	65+	20,753		
HH	Number of households	317762	household	Department of Statistics, Malaysia (2001) Valuation and Property Services Department, Malaysia (2006)
WR	Labour-force participation ratio		-	Department of Statistics, Malaysia (2006b)
	Male			
	15-64	0.824		
	65+	0.250		
	Female			
	15-64	0.460		
	65+	0.200		
LNtot	Number of workers by industry		person	estimated by Department of Statistics, Malaysia (2006d, 2006e)
	Agriculture	24,048		
	Mining	0		
	Food Products and Bevarages	14,284		
	Chemicals and Chemical Products	6,416		
	Electric and Electronic Products and Machinery	38,690		
	Fabricated Metal Products and Machinery	22,858		
	Other Non-Metallic	12,081		
	Rubber and Plastics Products	23,079		
	Construction	67,114		
	Transport related	44,998		
	Wholesale and Retail	144,146		
	Tourism and Hospitality	120,276		
	Professional and Business	13,374		
	Medical and Education	30,042		
	Other Services	16,350		
	Public administration	10,279		
PD	Output by industry		mil RM	estimated by Department of Statistics, Malaysia (2005, 2007) and Khazanah Nasional (2006)
	Agriculture	1,860		
	Mining	0		
	Food Products and Bevarages	9,228		
	Chemicals and Chemical Products	6,651		
	Electric and Electronic Products and Machinery	26,803		
	Fabricated Metal Products and Machinery	22,032		
	Other Non-Metallic	5,378		
	Rubber and Plastics Products	7,095		
	Construction	6,315		
	Transport related	7,226		
	Wholesale and Retail	11,358		
	Tourism and Hospitality	9,261		
	Professional and Business	3,887		
	Medical and Education	1,840		
	Other Services	1,705		
	Public administration	793		

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

Code in ExSS	Name	Value	Unit	Source
FA	Floor space of commercial buildings		m2	Valuation and Property Services Department, Malaysia (2006)
	Office	13,610		
	Shop	20,619		
	Hospital & school	1,840		
FA_G	Floor space of commercial buildings per output		m2/mil RM	estimated by floor space of commercial buildings and output of tertiary industry
	Office	43		
	Shop	275		
	Hospital & school	315		
	Number of motor vehicles		vehicle	Department of Statistics, Malaysia (2006b)
	Motorcar	329,663		
	Motocycle	394,127		
	Bus	3,118		
	Annual mileage per vehicle		km/vehicle/year	Fulton, L. and G. Eads (2004)
	Motorcar	10,000		p.33-34
	Motocycle	10,000		p.39
	Bus	40,000		p.61
	Number of passengers carried per vehicle per trip		person/vehicle/trip	Fulton, L. and G. Eads (2004)
	Motorcar	1.89		p.35
	Motocycle	1.65		p.39
	Bus	18.75		p.59,
PTG	Passenegr transport generation per person per day	2.25	trip/capita/day	
PTS	Modal share		-	The Federal Territory Development and Klang Valley Planning Division, et al. (1999), pp. 3-9
	Passenger railways	0.011		Ministry of Works, Malaysia (2006)
	Bus	0.015		
	Motorcar	0.534		
	Motorcycle	0.226		
	Walk	0.147		
	Bicycle	0.067		
PTAD	Average trip distance		km/trip	estimated by passenger transport volume, modal share, passenger transport generation per person per day, and population
	Passenger railways	1.8		
	Bus	4.0		
	Motorcar	4.0		
	Motorcycle	4.0		
	Walk	1.0		
	Bicycle	2.5		
PTD	Passenger transport volume		mil p-km	estimated by annual mileage per vehicle and the number of passengers per vehicle per trip
	Passenger railways	23		
	Bus	65		
	Motorcar	2,374		
	Motorcycle	1,005		
	Walk	163		
	Bicycle	186		
	Number of motor vehicles		vehicle	Department of Statistics, Malaysia (2006b)
	Freight vehicle	83,691		
	Annual mileage per vehicle		km/vehicle	Fulton, L. and G. Eads (2004), p.48
	Freight vehicle	31480		estimated by weighted average of annual mileage per vehicle of Heavy-duty truck and Medium-duty truck using composition ratio of the number of vehicles
	Load tonnage per vehicle per trip		t/vehicle/trip	Fulton, L. and G. Eads (2004), p.48
	Freight vehicle	2.93		estimated by weighted average of annual mileage per vehicle of Heavy-duty truck and Medium-duty truck using composition ratio of the number of vehicles
FTG	Freight transport generation per output	703	t/mil RM	
FTS	Modal share		-	estimated by freight transport volume
	Freight railways	0.003		
	Freight vehicle	0.997		
FTAD	Average trip distance		km/trip	
	Freight railways	56.8		
	Freight vehicle	27.4		
FTD	Freight transport volume		mil t-km	estimated by Department of Statistics, Malaysia (2006c), annual mileage per vehicle, and load tonnage per vehicle per trip
	Freight railways	11		
	Freight vehicle	1,642		

Appendix 3: Iskandar Malaysia 2005 Energy balance table (final demand sector)

Industry		Coal	Petroleum Products (total)	Gasoline	Naphtha	Jet Fuel	Kerosene	Diesel Oil	Heavy Oil	Lubricating Oil	LPG	Petrol. Hydro Carbon	Petrol. Coke	Natural gas	LNG	Renewables	Electricity	Total	Ratio of All Sector
Non-manufacturing	Agriculture	0.0	3.0	0.1	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0%
	Construction	0.0	31.8	0.1	0.0	0.0	0.2	20.4	9.8	0.0	1.3	0.1	0.0	23.2	0.0	0.0	14.1	69.1	2%
	Mining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manufacturing	Food Products and Bevarages	0.0	158.4	0.4	0.0	0.0	0.9	101.5	48.8	0.0	6.4	0.3	0.0	222.9	0.0	0.0	136.1	517.4	16%
	Chemicals and Chemical Products	0.0	147.3	0.4	0.0	0.0	0.8	94.4	45.4	0.0	6.0	0.3	0.0	51.1	0.0	0.0	31.2	229.6	7%
	Electric and Electronic Products and Machinery	0.0	22.6	0.1	0.0	0.0	0.1	14.5	7.0	0.0	0.9	0.0	0.0	125.7	0.0	0.0	76.8	225.0	7%
	Fabricated Metal Products and Machinery	0.0	39.4	0.1	0.0	0.0	0.2	25.2	12.1	0.0	1.6	0.1	0.0	54.3	0.0	0.0	33.2	126.9	4%
	Other Non-Metallic	49.7	34.2	0.1	0.0	0.0	0.2	21.9	10.5	0.0	1.4	0.1	0.0	25.9	0.0	0.0	15.8	125.5	4%
	Rubber and Plastics Products	0.0	242.4	0.7	0.0	0.0	1.4	155.4	74.7	0.0	9.8	0.4	0.0	120.4	0.0	0.0	73.5	436.3	13%
Total		49.7	679.0	1.9	0.0	0.0	3.8	436.2	208.4	0.0	27.4	1.2	0.0	623.4	0.0	0.0	380.7	1,732.9	53%

Residential	Coal	Petroleum Products (total)	Gasoline	Naphtha	Jet Fuel	Kerosene	Diesel Oil	Heavy Oil	Lubricating Oil	LPG	Petrol. Hydro Carbon	Petrol. Coke	Natural gas	LNG	Renewables	Electricity	Total	Ratio of All Sector
	0.0	46.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.8	0.0	0.0	0.3	0.0	0.0	192.9	240.0	7%

Commercial	Coal	Petroleum Products (total)	Gasoline	Naphtha	Jet Fuel	Kerosene	Diesel Oil	Heavy Oil	Lubricating Oil	LPG	Petrol. Hydro Carbon	Petrol. Coke	Natural gas	LNG	Renewables	Electricity	Total	Ratio of All Sector
	0.0	52.8	0.0	0.0	0.0	0.0	0.0	18.7	0.0	34.1	0.0	0.0	1.5	0.0	0.0	327.6	381.9	12%

Transport		Coal	Petroleum Products (total)	Gasoline	Naphtha	Jet Fuel	Kerosene	Diesel Oil	Heavy Oil	Lubricating Oil	LPG	Petrol. Hydro Carbon	Petrol. Coke	Natural gas	LNG	Renewables	Electricity	Total	Ratio of All Sector
Passenger	Passenger vehicle	0.0	322.8	200.0	0.0	0.0	0.0	122.8	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	325.0	10%
	Motorcar	0.0	287.6	178.2	0.0	0.0	0.0	109.4	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	289.6	9%
	Motorcycle	0.0	35.2	21.8	0.0	0.0	0.0	13.4	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	35.4	1%
	Bus	0.0	33.9	21.0	0.0	0.0	0.0	12.9	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	34.1	1%
	Rail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0%
	Ship																	0.0	0%
	Aviation																	0.0	0.0
Freight	Goods vehicle	0.0	568.3	352.1	0.0	0.0	0.0	216.2	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0	0.0	572.1	17%
	Rail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0%
	Ship																	0.0	0%
	Aviation																	0.0	0%
Total		0.0	925.0	573.1	0.0	0.0	0.0	351.8	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	0.2	931.4	28%

All Sector	49.7	1,703.6	575.0	0.0	0.0	3.8	788.1	227.1	0.0	108.3	1.2	0.0	631.6	0.0	0.0	901.4	3,286.2	100%

Appendix 4: Iskandar Malaysia 2005 IO table transactions valued at producer's price (1/2)

	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
Agriculture	175	0	1,686	232	5	14	561	472	7	2	9	1,059
Mining	0	0	0	139	2	107	83	2,521	214	0	1	0
Food Products and Bevarages	105	0	3,673	518	6	2	2	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 and Machinery	11	0	0	2	14,343	7,548	97	152	306	35	15	30
Fabricated Metal Products and Machinery	43	0	166	196	2,963	6,442	257	100	1,302	429	109	119
Other Non-Metallic	17	0	247	116	653	331	1,282	79	1,214	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
Medaical and Ecucation	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	0	0	1	1	0
Total intermediate input	731	0	7,458	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)

	Professional and Business	Medaical and Ecucation	Other Services	Public administration	Total intermediate input	Private consumption	Government consumption	Fixed capital formatio	Export	Import	Total final demand	Total use (domestic production)
Agriculture	5	1	11	0	4,238	797	0	65	443	-3,684	-2,379	1,860
Mining	3	0	2	0	3,074	5	0	154	0	-3,233	-3,074	0
Food Products and Bevarages	5	39	4	10	6,665	958	0	0	3,743	-2,138	2,563	9,228
Chemicals and Chemical Products	9	104	9	2	5,191	181	0	0	4,327	-3,046	1,461	6,651
Electric and Electronic Products and Machinery	23	8	147	4	22,721	467	0	441	22,503	-19,329	4,082	26,803
Fabricated Metal Products and Machinery	73	65	53	109	12,426	1,017	0	1,618	17,719	-10,749	9,606	22,032
Other Non-Metallic	99	62	25	39	4,413	1,093	0	71	3,445	-3,644	965	5,378
Rubber and Plastics Products	21	14	69	15	4,187	811	0	0	4,069	-1,972	2,908	7,095
Construction	21	42	39	39	1,129	33	0	2,098	3,168	-113	5,185	6,315
Transport related	31	16	30	16	3,444	530	0	9	4,693	-1,449	3,782	7,226
Wholesale and Retail	30	36	39	10	5,770	157	0	129	5,303	0	5,588	11,358
Tourism and Hospitality	26	19	11	18	1,235	1,043	0	0	6,984	0	8,027	9,261
Professional and Business	575	170	185	106	4,707	2,173	82	5	1,716	-4,796	-820	3,887
Medaical and Ecucation	82	41	65	1	1,756	100	875	0	14	-906	83	1,840
Other Services	134	76	132	42	2,807	832	73	0	133	-2,140	-1,103	1,705
Public administration	0	0	1	20	26	0	1,810	0	0	-1,044	766	793
Total intermediate input	1,139	691	823	432	83,790	10,195	2,840	4,590	78,259	-58,243	37,641	121,431
Compensation of Employee	641	1,073	168	344	12,023							
Operating Surplus	2,042	68	696	8	24,975							
Other value added	64	7	17	8	644							
Total value added	2,748	1,148	882	360	37,641							
Total input (domestic production)	3,887	1,840	1,705	793	121,431							

Appendix 6: Energy service demand per driving force and fuel share (1/3)

2005

Sector	Energy service	Basic unit	Fuel share					
			Coal	Petroleum	Gas	Renewables	Electricity	Total
Residential		0.755 toe/household	0%	20%	0%	0%	80%	100%
Commercial		55.835 ktoe/mil m^2	0%	14%	0%	0%	86%	100%
Industry	Agriculture	1.636	0%	100%	0%	0%	0%	100%
	Mining	-	-	-	-	-	-	-
	Food Products and Bevarages	56.062	0%	31%	43%	0%	26%	100%
	Chemicals and Chemical Products	34.520	0%	64%	22%	0%	14%	100%
	Electric and Electronic Products and Machinery	8.394	0%	10%	56%	0%	34%	100%
	Fabricated Metal Products and Machinery	5.759	0%	31%	43%	0%	26%	100%
	Other Non-Metallic	23.337	40%	27%	21%	0%	13%	100%
	Rubber and Plastics Products	61.498	0%	56%	28%	0%	17%	100%
	Construction	10.950 ktoe/mil RM	0%	46%	34%	0%	20%	100%
Passenger transport	Passenegr railways	0.005	0%	0%	0%	0%	100%	100%
	Bus	0.521	0%	99%	1%	0%	0%	100%
	Motorcar	0.122	0%	99%	1%	0%	0%	100%
	Motorcycle	0.035 ktoe/mil p-km	0%	99%	1%	0%	0%	100%
Freight transport	Freight railways	0.006	0%	0%	0%	0%	100%	100%
	Freight vehicle	0.348 ktoe/mil t-km	0%	99%	1%	0%	0%	100%

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.)

Sector	Energy service	Basic unit	Fuel share					
			Coal	Petroleum	Gas	Renewables	Electricity	Total
Residential		1.597 toe/household	0%	20%	0%	0%	80%	100%
Commercial		55.835 ktoe/mil m^2	0%	14%	0%	0%	86%	100%
Industry	Agriculture	1.636	0%	100%	0%	0%	0%	100%
	Mining	-	-	-	-	-	-	-
	Food Products and Bevarages	56.062	0%	31%	43%	0%	26%	100%
	Chemicals and Chemical Products	34.520	0%	64%	22%	0%	14%	100%
	Electric and Electronic Products and Machinery	8.394	0%	10%	56%	0%	34%	100%
	Fabricated Metal Products and Machinery	5.759	0%	31%	43%	0%	26%	100%
	Other Non-Metallic	23.337	40%	27%	21%	0%	13%	100%
	Rubber and Plastics Products	61.498	0%	56%	28%	0%	17%	100%
	Construction	10.950 ktoe/mil RM	0%	46%	34%	0%	20%	100%
Passenger transport	Passenegr railways	0.005	0%	0%	0%	0%	100%	100%
	Bus	0.020	0%	99%	1%	0%	0%	100%
	Motorcar	0.107	0%	99%	1%	0%	0%	100%
	Motorcycle	0.031 ktoe/mil p-km	0%	99%	1%	0%	0%	100%
Freight transport	Freight railways	0.006	0%	0%	0%	0%	100%	100%
	Freight vehicle	0.307 ktoe/mil t-km	0%	99%	1%	0%	0%	100%

Appendix 8: Energy service demand per driving force and fuel share (3/3)

2025CM

Sector	Energy service	Basic unit	Fuel share					
			Coal	Petroleum	Gas	Renewables	Electricity	Total
Residential		1.437 toe/household	0%	2%	5%	12%	81%	100%
Commercial		50.251 ktoe/mil m^2	0%	2%	7%	5%	86%	100%
Industry	Agriculture	0.986	0%	25%	75%	0%	0%	100%
	Mining	-	-	-	-	-	-	-
	Food Products and Bevarages	33.788	0%	8%	66%	0%	26%	100%
	Chemicals and Chemical Products	20.804	0%	16%	70%	0%	14%	100%
	Electric and Electronic Products and Machinery	5.059	0%	3%	63%	0%	34%	100%
	Fabricated Metal Products and Machinery	3.471	0%	8%	66%	0%	26%	100%
	Other Non-Metallic	14.065	40%	7%	41%	0%	13%	100%
	Rubber and Plastics Products	37.064	0%	14%	69%	0%	17%	100%
	Construction	6.600 ktoe/mil RM	0%	12%	68%	0%	20%	100%
Passenger transport	Passenegr railways	0.004	0%	0%	0%	0%	100%	100%
	Bus	0.018	0%	30%	50%	20%	0%	100%
	Motorcar	0.100	0%	30%	50%	20%	0%	100%
	Motorcycle	0.029 ktoe/mil p-km	0%	30%	50%	20%	0%	100%
Freight transport	Freight railways	0.005	0%	0%	0%	0%	100%	100%
	Freight vehicle	0.286 ktoe/mil t-km	0%	30%	50%	20%	0%	100%

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

2025BaU (2005=1)

Sector	Energy service	Inverse of energy efficiency					
		Coal	Petroleum	Gas	Renewables	Electricity	Total
Residential		1.00	0.91	0.91	1.00	1.00	0.91
Commercial		1.00	0.91	0.91	1.00	1.00	0.91
Industry	Agriculture	1.00	0.91	0.91	1.00	1.00	0.91
	Mining	1.00	0.91	0.91	1.00	1.00	0.91
	Food Products and Bevarages	1.00	0.91	0.91	1.00	1.00	0.91
	Chemicals and Chemical Products	1.00	0.91	0.91	1.00	1.00	0.91
	Electric and Electronic Products and Machinery	1.00	0.91	0.91	1.00	1.00	0.91
	Fabricated Metal Products and Machinery	1.00	0.91	0.91	1.00	1.00	0.91
	Other Non-Metallic	1.00	0.91	0.91	1.00	1.00	0.91
	Rubber and Plastics Products	1.00	0.91	0.91	1.00	1.00	0.91
	Construction	1.00	0.91	0.91	1.00	1.00	0.91
Passenger transport	Passenegr railways	1.00	0.91	0.91	1.00	1.00	0.91
	Bus	1.00	0.91	0.91	1.00	1.00	0.91
	Motorcar	1.00	0.91	0.91	1.00	1.00	0.91
	Motorcycle	1.00	0.91	0.91	1.00	1.00	0.91
Freight transport	Freight railways	1.00	0.91	0.91	1.00	1.00	0.91
	Freight vehicle	1.00	0.91	0.91	1.00	1.00	0.91

Appendix 10: Inverse of energy efficiency (2/2)

2025CM (2005=1)

Sector	Energy service	Inverse of energy efficiency					
		Coal	Petroleum	Gas	Renewables	Electricity	Total
Residential		1.00	0.98	0.89	1.00	1.00	0.52
Commercial		1.00	0.93	0.36	1.00	1.00	0.71
Industry	Agriculture	0.80	0.80	0.80	0.80	1.00	0.81
	Mining	-	-	-	-	-	-
	Food Products and Bevarages	0.80	0.80	0.80	0.80	1.00	0.81
	Chemicals and Chemical Products	0.84	0.84	0.84	0.84	1.00	0.81
	Electric and Electronic Products and Machinery	0.72	0.72	0.72	0.72	1.00	0.81
	Fabricated Metal Products and Machinery	0.74	0.74	0.74	0.74	1.00	0.81
	Other Non-Metallic	0.73	0.73	0.73	0.73	1.00	0.81
	Rubber and Plastics Products	0.80	0.80	0.80	0.80	1.00	0.81
	Construction	0.72	0.72	0.72	0.72	1.00	0.81
Passenger transport	Passenegr railways	1.00	1.00	1.00	1.00	1.00	1.00
	Bus	1.00	0.67	0.67	1.00	1.00	1.00
	Motorcar	1.00	0.71	0.71	1.00	1.00	1.00
	Motorcycle	1.00	0.71	0.71	1.00	1.00	1.00
Freight transport	Freight railways	1.00	1.00	1.00	1.00	1.00	1.00
	Freight vehicle	1.00	0.72	0.72	1.00	1.00	1.00

Appendix 11: Statistical data source used in this research

Statistics Name	Year of Publication	Organization	Type
Malaysia Environmental Quality Report 2005	2006	Department of Environment, Ministry of Natural Resources and Environment, Malaysia	PDF
Agriculture Census Malaysia 2005 -Crops	2006	Department of Statistics, Malaysia	CD
Annual National Accounts Gross Domestic Product (GDP) 2000-2007	2007	"	CD
Annual National Accounts Gross Domestic Product (GDP), Malaysia 2000-2006	2007	"	CD
Annual National Product and Expenditure Accounts, Malaysia 1987-2005	2006	"	CD
Annual Survey of Manufacturing Industries,Malaysia 2005	2006	"	CD
Census of Education Services (Private Sector) 2004	2005	"	Book
Census of Health Services Malaysia 2004	2005	"	Book
Compendium of Environmental Statistics Malaysia 2007	2007	"	Book
Compendium of Environmental Statistics, Malaysia 2006	2007	"	Book
Distribution and Use of Income Accounts and Capital Account Malaysia 2004	2007	"	Book
Economic Census 2006 (Accomodation)	2007	"	CD
Economic Census 2006 (Construction)	2007	"	CD
Economic Census 2006 (Education)	2007	"	CD
Economic Census 2006 (Health)	2007	"	CD
Economic Census 2006 (Information & Communications Technology)	2007	"	CD
Economic Census 2006 (Manufacturing)	2007	"	CD
Economic Census 2006 (Professional)	2007	"	CD
Economic Census 2006 (Selected Services)	2007	"	CD
Economic Census 2006 (Transportation & Communications)	2007	"	CD
Economic Statistics-Time Series, Malaysia 2005	2008	"	Book & CD
Gross Domestic Product (GDP) Third Quarter 2008	2008	"	Book
Information and Communications Technology Services Statistics 2004 Malaysia	2005	"	Book
Input-Output tables, Malaysia 1987	1994	"	CD
Input-Output tables, Malaysia 1991	2002	"	CD
Input-Output tables, Malaysia 2000	2005	"	CD
Labour Force Survey Report, Malaysia 2005	2006	"	CD
Labour Force Survey Report, Malaysia 2006	2005	"	CD
Malaysia Census of Professional Services (Private Sector) 2003	2005	"	Book
Malaysia Economic Statistics-Time Series 2005	2006	"	Book & CD
Malaysia Economic Statistics-Time Series 2007	2008	"	CD
Migration Survey Report, Malaysia 2003	2004	"	CD
Petroleum & Natural Gas Statistics, Malaysia 2005	2006	"	CD
Population and Housing Census of Malaysia 2000 -Household Caracteristics	2004	"	CD
Population and Housing Census of Malaysia 2000 -Population Distribution by Local Authority Areas and Mukims	2001	"	CD
Report on Household Expenditure Survey, Malaysia 2004/05	2006	"	Book & CD
Social Statistical Bulletin, Malaysia 2006	2006	"	Book & CD
State/District Data Bank, Malaysia 2006	2006	"	Book & CD
State/District Data Bank, Malaysia 2007	2008	"	CD
Survey of Construction Industries, Malaysia 2005	2006	"	CD
Time Series Data Population and Housing Census, 1911-2000	2006	"	Book
Transport and Communications Services Statistics, Malaysia 2005	2006	"	Book
Vital Statistics Malaysia 2007	2008	"	Book
Vital Statistics Time Series, Malaysia 1963-1998	2002	"	CD
Yearbook of Statistics, Malaysia 2006	2007	"	Book & CD
Yearbook of Statistics, Malaysia 2007	2008	"	CD
Yearbook of Statistics, Sarawak 2006	2007	"	Book & CD
Ninth Malaysia Plan 2006-2010	2006	Economic Planning Unit, Prime Minister's Department, Malaysia	PDF
Country Profile 2003 Malaysia	2003	Economist Intelligence Unit, U.K.	PDF
Country Profile 2007 Malaysia	2007		PDF
Country Profile 2008 Malaysia	2008		PDF
Country Profile Malaysia Burunei 1996-97	1996		PDF
Country Profile Malaysia Burunei 1999-2000	1999		PDF
Important Facts and Details on Iskandar Malaysia	2008	Iskandar Regional Development Authority	Book
Comprehensive Development Plan 2006-2025 for South Johor Economic Region	2006	Khazanah Nasional	PDF
Draft Kuala Lumpur City Plan 2020 Towards a World Class City	2008	Kuala Lumpur City Hall	DVD
National Energy Balance 2003 Malaysia	2005	Ministry of Energy, Water and Communications, Malaysia	Book
National Energy Balance 2004 Malaysia	2006		Book & CD
National Energy Balance 2005 Malaysia	2007		Book & CD
National Energy Balance 2006 Malaysia	2008		Book & CD
Malaysia Initial National Communication	2000	Ministry of Science, Technology and the Environment, Malaysia	CD
Road Traffic Volume Malaysia 2006	2006	Ministry of Works, Malaysia	CD
Property Market Report 2006	2007	Valuation and Property Services Department, Ministry of Finance, Malaysia	Book & CD
Property Market Report 2007	2008		Book & CD

Appendix 12: List of Set used in C-ExSS calculations

Set	Subset 1	Subset 2	Elements (Example)
sec	*SecNR*	*Com*	Office/Commercial complex
			Shop/Shop office
			Hotel
			Shopping mall
			Restaurant
			Mix development (housing + commercial)
			Petroleum station
			Service industry
			Private amenities
		Pub	Public kindergarten
			School
			Hospital/Clinic
			Mosque/Small mosque
			Fire Department
			Police station
			Neighbourhood Complex
			Food Court (landed)
			City service center
			Recycle center
			Market
			Utility
		Gov	Parcel A -PM's office
			Parcel B - Prime Minister's Department
			Parcel C - Ministry Of Science, Technology & Inovations & Other Agencies
			Parcel D
			Parcel E
			Parcel F
			2G1 - Ministry of Finance
			2G2 - Perbendaharaan & Kastam
			2C1 - Ministry of the federal territory and welfare of town
			2G3 - Ministry Of Dosmetic Trade and Cosumers Affair
			2G4 - Ministry Of PlantationsIndustries and Commodoties
			2G5 - National Registration Department
			2G6 - Ministry Of Entrepreneur and Co-operative Development (MEDC)
			2G7 - Foreign ministry
			2G8 - Housing loan department
			2C15 - Energy commission
			2C10 - Election commission
			3G1 - Department of Judiciary & Law Affairs
			3G2 - Putrajaya Corporation
			3G3 - Palace Of Justice
			3M2+C2+C3 - Pilgrimage fund boad complex
			4G1 - Ministry Of Agriculture and Agro - Based Industries)
			4G2 - Fisheries Department
			4G3 - Ministry Of Natural Resources and Environment
			4G4 - Ministry Of Youths and Sports
			4G5 - Ministry of road transportation
			4G7 - Attorney General's Chamber
			4G8 - Ministry of rural and regional development
			4G9 - Ministry of information, communication, arts, and culture
			4G10 - Ministry of housing and local government
			4G11 - Ministry of women, family, and community development
			5G2 - Ministry of higher education, and Ministry of tourism
			Other government building

Set	Subset 1	Subset 2	Elements (Example)
sec	*SecR*	*Res*	High income
			Middle income
			Low income
		PT	(Passenger transport)
		FT	(Freight transport)
esc	*esc1*		Cooling
			Lighting
	esc2		Hot water
			Cooking
			Other electric appliances
	ptm		Bicycle,Walk
			Motorcycle
			Automobile
			Bus
			Rail
	ftm		Freight vehicle
			Element
e			Electricity
			Petroleum
			LPG
			Natural gas
			Coal
			Coal(CCS)
			Nuclear
			Solar heat
			Other renewable
goods			Food and Non-Alcoholic Beverages
			Alcoholic Beverages and Tobacco
			Clothing and Footwear
			Housing, Water, Electricity, Gas and Other Fuels
			Furnishings, Household, Equipment and Routine Household Maintenance
			Health
			Transport
			Communication
			Recreation Services and Culture
			Education
			Restaurants and Hotels
			Miscellaneous Goods and Services
dev	*devcon*		(conventional devices)
	deche		(high efficiency devices)

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

Parameter	Set	Explanation	Unit
Socio-economic			
FA	*sec*	Floor area	m^2
HHD	*secR*	Number of household	Household
LN	*secA*	Number of employment	Person
Pop	*secR*	Population	Person
Pphhd	*secR*	Household size	Person
INprs	*secNR*	Number of people commute into the area per day	no.
Sal	*com*	Sales	monetary
Sal_S	*com*	Sales share in total sales of all activity	-
Exp_hhd	*secR*	Expenditure per household per year	Mill. Monetary/year
Passenger transport			
PTD	*ptm*	Passenger transport demand	Mill.pass-km
PTG	-	Passenger transport generation	trip/person/day
PTS	*ptm*	Modal share of passenger transport	-
PTAD	*ptm*	Passenger transport average distance	km/trip
Freight transport			
FTD	*ftm*	Freight transport demand	Mill.t-km
Energy			
ESDF	*sec (See also Table4)*	The amount of activities	(See also Table4)
ESVG	*sec,esc*	Energy service generation	(See also Table4)
ESVD	*sec,esc*	Energy service demand	ktoe
ESVD_e	*sec,service, e*	Detailed energy service demand by fuel	ktoe
FS	*sec,service, e*	Fuel share in the service	-
EE	*sec,service, e*	Energy efficiency	-
ED	*sec,service, e*	Energy demand	ktoe
Dispersed power generation			
ED_dpg	*sec*	Energy demand for electricity generated by dispersed power generation	ktoe
EE_dpg	*sec*	Performance of dispersed power generation	$ktoe/m^2$
Dif_dpg	*sec*	Diffusion of dispersed power generation	m^2
Carbon accumulation			
CO2_acm	-	Accumulated CO_2 by trees	tCO_2
Tree	-	Number of trees existing in the area	tree
CA	-	CO_2 accumulation ability by tree	tCO_2/tree

Parameter	Set	Explanation	Unit
CO_2			
CO2EF	*e*	CO_2 emission factor	tCO_2/ktoe
CO2	*sec,e*	CO2 emission	tCO_2
Cost			
DESVD	*sec,esc,dev*	Energy service demand of device	ktoe
Dif^{BaU}	*sec,esc,dev*	Diffusion rate of device in BaU case	-
Dif^{CM}	*sec,esc,dev*	Diffusion rate of device in CM case	-
UD	*sec,esc,dev*	Unit demant of device	
SQ	*sec,esc,dev*	Supply quantity per unit of device	ktoe/unit
CST_add	*sec,esc*	Additional cost	Thou.monetary
CSTuni_dev	*sec,esc,dev*	Cost to introduce a unit of device	Thou.monetary/unit
LT_dev	*sec,esc,dev*	Life time of device	year
CST_dpg	*sec*	Additional cost to introduce dispersed power generation equipment	Thou.monetary/unit
ESVD_dpg	*sec*	Energy service demand from dispersed power generation equipment	ktoe
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	Thou.monetary/kW
LT_dpg	*sec*	Life time of dispersed power generation equipment	
CST_bat	*sec*	Additional cost to introduce battery	Thou.monetary/year
Cap	*sec*	Needed capacity of battery per rated system power of dispersed power generation equipment	kWh/kW
CSTuni_bat	*sec*	Cost to introduce battery per capacity	Thou.monetary/kW
LT_bat	*sec*	Life time of battery	
CST_e	*e*	Reduced energy cost	monetary
CSTuni_e	*e*	Cost of energy	

Appendix 14: CO_2 emission factor

	2007	2025BaU	2025CM
Electricity [tCO_2/GWh]	560	563	458
Petroleum [tCO_2/toe]	2.8	2.8	2.8
LPG [tCO_2/toe]	2.7	2.7	2.7
Natural gas [tCO_2/toe]	2.1	2.1	2.1

Appendix 15: List of countermeasures (1/5)

Sector	Countermeasure No.	Action******	Low-carbon countermeasure	Performance		Information source of performance	Cost [1000US$]	Information source of cost	Diffusion [%]*	CO_2 emission reduction [tCO_2]	Contribution in the sector [%]	Contribution in total reduction [%]
Commercial			Cooling							57,164	12.7%	2.4%
	(1)	3	High efficiency heat pump air conditioner	COP	6.4	(q)	3.01 [/unit]	(s)	60%			
	(2)	3	District cooling	COP	1.4	(a)	1.02 [/unit]	(s)	30%			
			Hot water							59,487	13.2%	2.5%
	(3)	3	High efficiency electric boiler	COP	3.0	(b)	3.75 [/unit]	(s)	50%			
			Cooking							7,352	1.6%	0.3%
	(4)	3	High efficiency Cooking	Thermal efficiency	0.6	(b)	3.20 [/unit]	(s)	40%			
	(5)	3	IH cooking heater	Thermal efficiency	0.9	(j)	1.84 [/unit]	(s)	30%			
			Lighting							64,376	14.3%	2.7%
	(6)	3	LED (substitute incandescent light)	Energy consumption (conventional type=1)	4.6	(j)	0.11 [/unit]	(s)	50%			
	(7)	3	Other electric appliances***	Energy consumption (conventional type=1)	1.7	(c)	2.57 [/unit]	(s)	50%	155,924	34.5%	6.5%
	(8)	3	BEMS**	Energy service demand reduction rate	10%	(k)	0.0018 [/unit]	(y)	40%	102,282	22.6%	4.3%
	(9)	3	Building insulation	Energy service demand reduction rate	50%	(j)	0.01 [/unit]		50%			
	(10)	3	Energy saving behavior**	Energy service demand reduction rate	10%	(m)		-	30%			
	(11)	8	UHI countermeasure	Energy service demand reduction rate	11%	(d)						
	(12)	4	Photovoltaic power generation at buildings	[ktoe/Mill.m^2]	8.5	(e)	1.09 [/kWp]	(t) (u)	10%	5,114	1.1%	0.2%
	Subtotal									**451,699**	**100%**	**18.8%**

Appendix 16: List of countermeasures (2/5)

Sector	Countermeasure No.	Action*****	Low-carbon countermeasure	Performance		Information source of performance	Cost [1000US$]		Information source of cost	Diffusion [%]*	CO_2 emission reduction [tCO_2]	[%] Contribution in the sector [%]	Contribution in total reduction
Public amenities & facilities			Cooling								22,013	23.5%	0.9%
	(1)	3	High efficiency heat pump air conditioner	COP	6.44	(q)	3.01	[/unit]	(s)	70%			
			Hot water								9,182	9.8%	0.4%
	(3)	3	High efficiency electric boiler	COP	3	(b)	3.75	[/unit]	(s)	50%			
			Cooking								954	1.0%	0.0%
	(4)	3	High efficiency Cooking	Thermal efficiency	0.56	(b)	3.20	[/unit]	(s)	40%			
	(5)	3	IH cooking heater	Thermal efficiency	0.90	(j)	1.84	[/unit]	(s)	30%			
			Lighting								8,547	9.1%	0.4%
	(6)	3	LED (substitute incandescent light)	Energy consumption (conventional type=1)	4.55	(j)	0.11	[/unit]	(s)	50%			
	(7)	3	Other electric appliances***	Energy consumption (conventional type=1)	1.67	(c)	2.57	[/unit]	(s)	60%	24,842	26.6%	1.0%
	(8)	3	BEMS**	Energy service demand reduction rate	10%	(k)	0.0018	[/unit]	(y)	40%	25,492	27.3%	1.1%
	(9)	3	Building insulation	Energy service demand reduction rate	50%	(j)	0.0077	[/unit]	(z)	50%			
	(10)	3	Energy saving behavior**	Energy service demand reduction rate	10%	(m)			-	30%			
	(11)	8	UHI countermeasure	Energy service demand reduction rate	11%	(d)							
	(12)	4	Photovoltaic power generation at buildings	[ktoe/Mill.m^2]	8.5	(e)	1.09	[/kWp]	(t) (u)	10%	2,491	2.7%	0.1%
	Subtotal										**93,521**	**100%**	**3.9%**
Government departments			Cooling								15,545	8.4%	0.6%
	(2)	3	District cooling	COP	1.4	(a)	1.02	[/unit]	(s)	70%			
			Hot water								16,966	9.2%	0.7%
	(3)	3	High efficiency electric boiler	COP	3.0	(b)	3.75	[/unit]	(s)	60%			
			Cooking								1,233	0.7%	0.1%
	(4)	3	High efficiency Cooking	COP	0.56	(b)	3.20	[/unit]	(s)	40%			
	(5)	3	IH cooking heater	COP	0.90	(j)	1.84	[/unit]	(s)	30%			
			Lighting								15,061	8.2%	0.6%
	(6)	3	LED (substitute incandescent light)	Energy consumption (conventional type=1)	4.6	(j)	0.11	[/unit]	(s)	60%			
	(7)	3	Other electric appliances***	Energy consumption (conventional type=1)	1.7	(c)	2.37	[/unit]	(s)	60%	42,558	23.1%	1.8%

Appendix 17: List of countermeasures (3/5)

Sector	Countermeasure No.	Action*****	Low-carbon countermeasure	Performance		Information source of performance	Cost [1000US$]		Information source of cost	Diffusion [%]*	CO_2 emission reduction [tCO_2]	Contribution in the sector [%]	Contribution in total reduction [%]
Government departments	(8)	3	BEMS**	Energy service demand reduction rate	0.1	(k)	0.0018	[/unit]	(y)	60%	55,941	30.3%	2.3%
	(9)	3	Building insulation	Energy service demand reduction rate	0.5	(j)	0.008	[/unit]	(z)	70%			
	(10)	3	Energy saving behavior**	Energy service demand reduction rate	0.1	(m)			-	35%			
	(11)	8	UHI countermeasure	Energy service demand reduction rate	0.1	(d)							
	(12)	4	Photovoltaic power generation at buildings	[ktoe/Mill.m^2]	8.5	(e)	1.09	[/kWp]	(t) (u)	100%	37,028	20.1%	1.5%
Subtotal											**184,332**	**100%**	**7.7%**
Residential			Cooling								3,145	4.1%	0.1%
	(1)	3	High efficiency heat pump air conditioner	COP	6.44	(q)	1.73	[/unit]	(s)	60%			
			Hot water								2,279	2.9%	0.1%
	(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%			
			Cooking								866	1.1%	0.0%
	(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%			
			Lighting								5,692	7.4%	0.2%
	(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%	42,752	55.3%	1.8%
	(14)	3	HEMS**	Energy service demand reduction rate	10%	(k)	0.09	[/unit]	(x)	30%	16,870	21.8%	0.7%
	(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.m^2]	8.5	(e)	1.09	[/kWp]	(t) (u)	6%	5,701	7.4%	0.2%
Subtotal											**77,305**	**100%**	**3.2%**

Appendix 18: List of countermeasures (4/5)

Sector	Countermeasure No.	Action******	Low-carbon countermeasure	Performance		Information source of performance	Cost [1000US$]		Information source of cost	Diffusion [%]*	CO_2 emission reduction [tCO_2]	Contribution in the sector [%]	Contribution in total reduction [%]
Passenger transport			Efficiency improvement of motorcycles, automobiles, buses								386,031	41.1%	16.1%
	(16)	2	High efficiency motorcycle	Energy efficiency [Mill.pass-km/ktoe]	17	(g)	0.56	[/unit]	(aa)	70%			
	(17)	2	High efficiency internal combustion vehicle	Energy efficiency [Mill.pass-km/ktoe]	12	(h)	2.20	[/unit]	(s)	15%			
	(18)	2	Hybrid vehicle	Energy efficiency [Mill.pass-km/ktoe]	12	(b)	2.28	[/unit]	(s)	25%			
	(19)	2	Electric vehicle	Energy efficiency [Mill.pass-km/ktoe]	29	(b)	3.31	[/unit]	(s)	20%			
	(20)	2	High efficiency natural gas vehicle	Energy efficiency [Mill.pass-km/ktoe]	20	(f)	2.21	[/unit]	(s)	10%			
	(21)	2	High efficiency natural gas bus	Energy efficiency [Mill.pass-km/ktoe]	216	(f)	15.04	[/unit]	(s)	50%			
	(22)	2	Efficiency improvement of trains	Energy efficiency [Mill.pass-km/ktoe]	532	(h)	10.00	[/unit]	(s)	60%	8,617	0.9%	0.4%
			Modal shift								285,739	30.4%	11.9%
	(11)	8	UHI countermeasure			(d)							
	(23)	2	Enhancement of bus system			(o)							
	(24)	1	Pedestrian-friendly city development (Mo			(o)							
	(25)	2	Introduction of new rail line			(o)							
			Shorter trip distance								258,708	27.5%	10.8%
	(25)	2	Introduction of new rail line			(o)							
	(27)	1	Mixed use development (Shorter trip distance)	Energy service demand reduction rate		(b)							
	(28)	2	ITS	Energy service demand reduction rate	10%	(o)	1853	[1000 US$]	(ab) (ac)				
				Energy efficiency improvement rate	10%	(o)							
	Subtotal										**939,095**	**100%**	**39.0%**
Freight transport			Efficiency improvement of freight vehicle								40,258	60.2%	1.7%
	(29)	-	High efficiency freight vehicle	Energy efficiency [Mill.t-km/ktoe]	21	(j)	12.73	[/unit]	(s)	99%			
	(30)	-	High efficiency bio-diesel freight vehicle	Energy efficiency [Mill.t-km/ktoe]	26	(r)	12.73	[/unit]	(s)	1%			
		-	Efficiency improvement of logistics	Energy service demand reduction rate	20%	(p)					26,657	39.8%	1.1%
	(28)	2	ITS	Energy service demand reduction rate	10%	(o)	1853	[1000 US$]	(ab) (ac)				
				Energy efficiency improvement rate	10%	(o)							
	Subtotal										**66,915**	**100%**	**2.8%**

Appendix 19: List of countermeasures (5/5)

Sector	Countermeasure No.	Action******	Low-carbon countermeasure	Performance	Cost [1000US$]	Information source of performance	Diffusion [%]*	Information source of cost	CO_2 emission reduction [tCO_2]	Contribution in the sector [%]	Contribution in total reduction [%]
Others****	(32)	-	Central power generation	CO_2 emission factor [tCO_2/ktoe]	5,323	(n)			332,640		13.8%
	(33)	6	Carbon sink (Tree planting)			(i)			35,420		1.5%
	(34)	9& 11	Solid waste management*****						224,150		9.3%
Total									**2,405,077**		

* "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 CO_2 reductions by Actions.

***** Its CO_2 emission reduction includes other GHG converted in tCO_2. It is excluded from targeted CO_2 emission reduction in "Low-carbon Putrajaya"(60% reduction).

Information sources

(a) Tokyo Gas Co., Ltd., *et al*.(2010): About joint development of high efficiency heat pomp.http://www.tokyo-gas.co.jp/Press/20100215-01.html

(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.

(c) Kyoto Mechanisms Promotion Department New Energy and Industrial Technology Development Organization (2008): Japanese Technologies for Energy Savings/GHG Emissions Reduction《2008 Revised Edition》.

(d) Saidur R, Masjuki H.H, Jamaluddin M.Y, Tamjis MRT (2006): Cooling Degree day Analysis for Malaysia.

(e) ASEAN Centre for Energy (2006): ASEAN Energy Efficiency and Conservation.

(f) Tokyo Gas Co., Ltd. (2010): About developing “Natural gas hybrid vehicle”. (http://www.tokyo-gas.co.jp/Press/20101109-01.html)

(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, Ver1.

(i) IPCC (2006): 2006 IPCC Guidelines for National Greenhouse Gas inventories, 4.

(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-

(l) Ministry of the Environment, Japan (2001): Report of the study team for scenario formulation of greenhouse gas reduction technologies, 2000

(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

(r) Okayama city, Japan (2010): Report on commercializing bio diesel fuel production feasibility study 2010.

(s) Hanaoka, T., Y. Matsuoka, M. Kainuma, K. Fujiwara, G. Hibino, T. Hasegawa, Y. Kanamori, and O. Akashi (2008): Global Greenhouse Gas Emissions Reduction Potentials and Mitigation Costs in 2020 -Methodology and Results-.

(t) International Energy Agency (IEA) (2010): Energy Technology Perspectives.

(u) phoenix SOLAR（website）: http://www.phoenixsolar.com/export/sites/com/sg/References/Downloads/CaseStudy-ECBldg-0911-LR.pdf

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

Battery RM2010
(w) Tsuji, E. (2009): Estimation of CO2 emission reduction by sharing battery for Photovoltaic power generation (Master thesis).
(x) NEC corporation (Website): http://www.nec.co.jp/press/ja/1010/0801.html
(y) The Energy Conservation Center, Japan (2005): Report on research about energy saving technology promotion project. http://www.asahikasei-kenzai.com/akk/insulation/neoma/wood/trial_calculation.html
(z) Asahi Kasei Corporation (Website): http://www.asahikasei-kenzai.com/akk/insulation/neoma/wood/trial_calculation.html
(aa) Honda Motor Co., Ltd. (Website): http://www.honda.co.jp/FAZE/
(ab) Ministry of Land, Infrastructure, Transport and Tourism, Japan (2008): Summary of ITS countermeasure
(ac) National Institute of Population and Social Security Research (Website): Population estimation in Japan (2001~2050). http://www.ipss.go.jp/pp-newest/j/newest02/3/t_1.html
(ad) Todai Policy Alternatives Research Institute (2009): Selected policy on energy & environment: towards coordination between technology policy and developing social system.

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

	Sub-action		Programs
1-1	**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
1-2	**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
1-3	**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)
1-4	**Residential Layout Planning**	1)	Orientation/ Alignment of the House/Building
		2)	Introduce residential element within other development plots (SOHO)
1-5	**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)
1-6	**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)

Appendix 21: List of Sub-actions & Programs in Action 2

	Sub-action		Programs
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
		5)	Transportation System (APTS).
		6)	To implement bus junction priority
		7)	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

	Sub-action	Programs
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.)
3-2	**Building Energy Management System (BEMS)***	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.
3-3	**Eco friendly Building Materials**	1) To look not only at the design of the building, but also the interior design and maintenance of the building.
3-4	**To integrate Recycling facilities in building designs.**	1) 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)
3-5	**Impose Building Rating System to all Buildings**	1) 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.

Appendix 23: List of Sub-actions & Programs in Action 4

	Sub-action	Programs
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)

	Sub-action	Programs
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)

	Sub- action	Programs
5- 5	**Research & Development for RE for Local consumption**	1) To study the feasibility of using water from lake for thermal sink (lower temperature of the lake bed water) for GDC operation (Presint 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

	Sub- action	Programs
6- 1	**To develop an Action Plan for urban reforestation**	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
6- 3	**To encourage Greenfrastructure Management in City Planning practices.**	1) Urban Forest - Plant selection contributing to carbon sink - saff flower - Urban Forest Management Plan 2) Wetlands-plant selection contributing to carbon sink 3) Lake - Water harvesting for irrigation 4) Parks & Open Spaces - introduce plant with highest carbon sink (bamboo) 5) To regulate the use of GDC in all commercial buildings within the CBD. Gas District Cooling (GDC) 6) Rainwater Harvesting
6- 4	**To develop a detailed Tree Inventory Database.**	1) To collect these data : - No of Trees Planted - Species of Trees Planted - Diameter of Trees - Growth Speed 2) To derive the Carbon Accounting from the Inventory data.
6- 2	**To ensure connectivity between fragmented forests**	1) Create wild life crossings and animal bridges 2) Enhance ecology
6- 5	**Innovation and Research & Development**	1) Explore possibilities of using green areas, lake and wetland as carbon sink. 2) Extensively promote roof top and vertical gardens 3) Conduct Research & Development activities on tree selection, maintenance, carbon sequestration, carrying capacity, etc. 4) Composting of tree waste below ground as Carbon Storage.

Appendix 27: List of Participants (1/2)

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

Appendix 28: List of Participants (2/2)

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

Appendix 29: Articles on National (Malaysian) News Paper about Actions Implemented

http://thestar.com.my/
Thursday October 20, 2011 MYT 6:31:00 PM

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

Appendix 30: Articles on National (Malaysian) News Paper about Actions Implemented

All government offices to keep air-conditioning temperature at 24ºC from now

By ZUHRIN AZAM AHMAD
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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.

Cool plan: Najib chairing the Green Technology and Climate Change Council meeting in Putrajaya yesterday while Chin (on his right) looks on.

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.

thestar online

Policy over temperature limit gets warm reception

By WANI MUTHIAH, MAZWIN NIK ANIS and WONG PEK MEI
newsdesk@thestar.com.my
Friday August 12, 2011

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 ($\overline{factor}$) are exogenous variables or parameters, so users need to input those data.

Base year

Demography and Economy

(1) Sales

$$Sal_{com} = \sum_{secR,goods} (\overline{Exp\_hhd_{\sec R,goods}} \times \overline{HHD_{\sec R}}) \times 10^6 \times (\overline{LN_{com}} / \sum_{com} \overline{LN_{com}}) \quad (1)$$

Where,

Salcom : Sales of sector *com* [monetary]

$\overline{Exp\_hhd_{\sec R,goods}}$: Expenditure per household of sector *secR* [Mill.monetary]

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

$\overline{LN_{com}}$: The number of employment [person]

Com : Commercial sector

secR: Residential sector

goods: Goods for household

(2) Sales share

$$Sal\_S_{com} = Sal_{com} / \sum_{com} Sal_{com} \quad (2)$$

Where,

$\overline{Sal\_S_{com}}$: Sales share of sector *com* in total sales [-]

Passenger transport

(1) Passenger transport demand

$$PTD_{ptm} = (\sum_{\sec NR} \overline{INprs_{\sec NR}} + \sum_{\sec R} \overline{Pop_{\sec R}}) \times \overline{PTG} \times \overline{PTS_{ptm}} \times PTAD_{ptm} \times 365/10^6 \quad (3)$$

Where,

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

$\overline{INprs_{\sec NR}}$: In-coming persons to sector *secNR* [person]

$\overline{Pop_{\sec R}}$: Population in sector *secR* [person]

$\overline{PTG}$: Passenger trip generation per person per day [trip/person/day]

$\overline{PTS_{ptm}}$: Modal share of passenger transport mode *ptm* [-]

$PTAD_{ptm}$: Average trip distance of passenger transport mode *ptm* [km/trip]

sec : Sector

ptm : Passenger transport mode

Freight transport demand

$\overline{FTD_{ftm}}$ (Freight transport demand by freight transport mode *ftm* [t-km]) is exogenous variable.

Energy demand

(1) Driving force of energy demand sectors

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

$\overline{ESDF_{\sec}}$; the amount of activities of energy demand sectors

Sector	Service	ESDF
SecNR	*esc*	$\overline{FA_{\sec NR}}$
SecR	*esc1*	$\overline{FA_{\sec R}}$
	esc2	$\overline{Pop_{\sec R}}$
PT	*ptm*	PTD_{ptm}
FT	*ftm*	$\overline{FTD_{ftm}}$

Where,

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

Pop_{secR} : *Population of sector secR [person]*

PTDptm : Passenger transport demand by passenger transport mode ptm [Mill.pass-km]

$\overline{FTD_{ftm}}$ *:* Freight transport demand by freight transport mode *ftm* [t-km]

(2) Energy service generation

$$ESVG_{sec,esc} = \overline{ESDF_{sec}} / ESVD_{sec,esc} \quad (4)$$

Where,

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

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

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

(3) Energy service demand

$$ESVD\_e_{sec,esc,e} = \overline{ED_{sec,esc,e}} / \overline{EE_{sec,esc,e}} \quad (5)$$

$$ESVD_{sec,esc} = ESVD\_e_{sec,esc,e} / \sum_{e} ESVD\_e_{sec,esc,e} \quad (6)$$

Where,

$ESVD\_e_{sec,esc,e}$: Energy service demand by fuel *e*, of service *esc* , by sector *sec* [ktoe]

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

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

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

sec : Sector

esc : Service

e : Fuel

(4) Fuel share

$$FS_{sec,esc,e} = ESVD\_e_{sec,esc,e} / \sum_{e} ESVD\_e_{sec,esc,e} \quad (7)$$

Where,

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

$ESVD\_e_{sec,esc,e}$: Energy service demand by fuel *e*, of service *esc* , by sector *sec* [ktoe]

sec : Sector

esc : Service

e : Fuel

CO_2 emission

$$CO2_{sec,e} = \left\{ (\sum_{esc} \overline{ED_{sec,esc,e}}) - \overline{ED\_dpg_{sec}} \right\} \times \overline{CO2EF_e} \quad (8)$$

Where,

$CO2_{sec,e}$: CO_2 emission [tCO_2]

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

ED_dpg_{sec} : Energy demand for electricity generated by dispersed power generation [ktoe]

$\overline{CO2EF_e}$: CO_2 emission factor of fuel e [tCO_2/ktoe]

Target year

Demography and Economy

(1) Household number

$$HHD_{\sec R} = \overline{Pop_{\sec R}} / \overline{Pphhd_{\sec R}} \quad (9)$$

Where,

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

$\overline{Pop_{\sec R}}$: Population [no.]

$\overline{Pphhd_{\sec R}}$: Household size of sector *secR* [person/household]

secR : Residential sector

(2) Sales

$$Sal_{com} = \sum_{secR,goods} (\overline{Exp\_hhd_{\sec R,goods}} \times HHD_{\sec R}) \times 10^6 \times \overline{Sal\_S_{com}} \quad (10)$$

Where F,

Sal_{com} : Sales of sector *com* [monetary/year]

$\overline{Exp\_hhd_{\sec R,goods}}$: Expenditure on goods, per household of sector *secR* [Mill. Monetary/year]

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

$\overline{Sal\_S_{com}}$: 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

$$ESVD_{sec,esc} = \overline{ESDF_{sec}} \times ESVG_{sec,esc} \quad (11)$$

Where,

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

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

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

(3) Energy service demand by fuel

$$ESVD\_e_{sec,esc,e} = ESVD_{sec,esc} \times \overline{FS_{sec,esc,e}} \quad (12)$$

Where,

$ESVD\_e_{sec,esc,e}$: 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] $\overline{FS_{sec,esc,e}}$: 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]

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

sec : Sector

esc : Service

e : Fuel

(4) Energy demand

$$ED_{sec,esc,e} = ESVD\_e_{sec,esc} \times \overline{EE_{sec,esc,e}} \quad (13)$$

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]

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

sec : Sector

esc : Service

e : Fuel

Carbon accumulation

$$CO2\_acm = \overline{Tree} \times CA \quad (14)$$

Where,

$CO2\_acm$: Accumulated CO_2 by trees [tCO_2]

$\overline{Tree}$: The number of trees existing in the area [tree.]

CA: CO_2 accumulation ability per tree [tCO_2/tree]

Dispersed power generation

$$ED\_dpg_{sec} = \overline{EE\_dpg_{sec}} \times \overline{Dif\_dpg_{sec}} \quad (15)$$

Where,

ED_dpg_{sec} : Energy demand for electricity generated by dispersed power generation [ktoe]

$\overline{EE\_dpg_{sec}}$: Performance of dispersed power generation [ktoe/m^2]

$\overline{Dif\_dpg_{sec}}$: Diffusion of dispersed power generation [m^2]

CO_2 emission

$$CO2_{sec,e} = \left\{ (\sum_{esc} ED_{sec,esc,e}) - \overline{ED\_dpg_{sec}} \right\} \times \overline{CO2EF_e} - CO2\_acm \quad (16)$$

Where,

$CO2_{sec,e}$: CO_2 emission [tCO_2]

ED_dpg_{sec} : Energy demand for electricity generated by dispersed power generation [ktoe]

$\overline{CO2EF_e}$: CO_2 emission factor of fuel e [tCO_2/ktoe]

$CO2\_acm$: Accumulated CO_2 by trees [tCO_2]

Abatement cost

(1) Devices

$$DESVD_{sec,esc,devcon} = ESVD_{sec,esc} \times \overline{Dif^{BaU}_{sec,esc,devcon}} \quad (17)$$

$$DESVD_{sec,esc,devcon} = ESVD_{sec,esc} \times \overline{Dif^{CM}_{sec,esc,devcon}} \quad (18)$$

$$UD_{sec,esc,dev} = DESVD_{sec,esc,dev} / \overline{SQ_{sec,esc,dev}} \quad (19)$$

$$CST\_dev_{sec,esc} = \sum_{devhe} (UD_{sec,esc,devhe} \times \overline{CSTuni\_dev_{sec,esc,devhe}} / \overline{LT\_dev_{sec,esc,devhe}}) - \sum_{devcon} (UD_{sec,esc,devcon} \times \overline{CSTuni\_dev_{sec,esc,devcon}} / \overline{LT\_dev_{sec,esc,devcon}}) \quad (20)$$

Where,

$DESVD_{sec,esc,dev}$: Energy service demand by sector *sec*, service *esc*, device *dev* [ktoe]

$\overline{Dif^{BaU}_{sec,esc,dev}}$: Diffusion rate of device *dev* in sector *sec*, service *esc* in BaU case [-]

$\overline{Dif^{CM}_{sec,esc,dev}}$: 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.]

$\overline{SQ_{sec,esc,dev}}$: 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]

$\overline{CSTuni\_dev_{sec,esc,dev}}$: Cost to introduce a unit of device *dev* in sector *sec*, service *esc* [Thou.monetary/unit]

$\overline{LT\_dev_{sec,esc,dev}}$: Life time of device 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

$$CST\_dpg_{sec} = \left(ESVD\_dpg_{sec} / \overline{ES\_R_{sec}} \times \overline{CSTuni\_dpg_{sec}}\right) / \overline{LT\_dpg_{sec}} \quad (21)$$

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]

$\overline{ES\_R_{sec}}$: Annual Energy yield per rated system power [kWh/kW]

$\overline{CSTuni\_dpg_{sec}}$: Cost to introduce dispersed power generation equipment per rated system power in sector *sec* [Thou.monetary/kW]

$\overline{LT\_dpg_{sec}}$: Life time of dispersed power generation equipment in sector *sec* [year]

sec : Sector

(3) Smart grid

$$CST\_bat_{sec} = \left(RESVD_{sec} / \overline{Cap_{sec}} \times \overline{CSTuni\_bat_{sec}} \right) / \overline{LT\_bat_{sec}} \quad (22)$$

Where,

CST_bat_{sec} : Additional cost to introduce battery [Thou.monetary/year]

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

$\overline{CSTuni\_bat_{sec}}$: Cost to introduce battery per capacity in sector *sec* [Thou.monetary/kW]

$\overline{LT\_bat_{sec}}$: Life time of battery in sector *sec* [year]

sec : Sector

(4) Reduction of energy cost

$$CST\_e_e = \left(\sum_{sec,esc} ED^{BaU}{}_{sec,esc,e} - \sum_{sec,esc} ED^{CM}{}_{sec,esc,e} \right) \times \overline{CSTuni\_e_e} / 10^{-6} \quad (23)$$

Where,

CST_e_e : Reduced energy cost of fuel *e* [Mill. US$]

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

$\overline{CSTuni\_e_e}$: Cost of energy [US$/ktoe]

sec : Sector

esc : Service *e* : Fuel