LOW CARBON CITIES

FRAMEWORK & ASSESSMENT SYSTEM

KeTTHA

KEMENTERIAN TENAGA, TEKNOLOGI HIJAU DAN AIR

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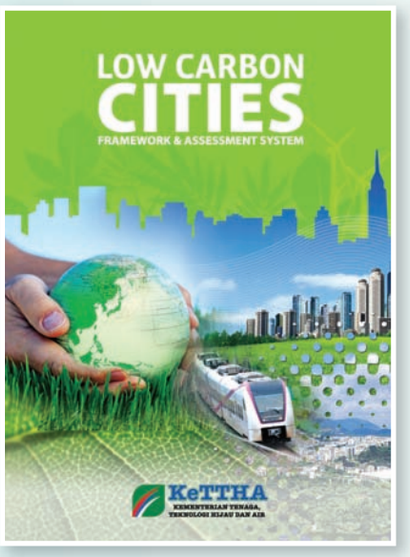

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In an effort to improve this document further, this version 1.0 will be updated periodically.

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In Collaboration With:

Green Tech Malaysia

Malaysian Institute of Planners

Foreword

It gives me great pleasure to introduce this publication known as the Low Carbon Cities Framework and Assessment System (LCCF). The Government recognizes the need and importance of achieving long term sustainability in providing conducive environment to the people. Malaysia has managed to launch several policies related to environmental protection. These policies reflect the government initiatives on sustainable growth and development that provide direction and motivation for Malaysians towards greener solutions

.

Most governments of the world have recognized the need to establish and implement national sustainable development programmes that requires high participatory instruments intended to ensure socially responsible economic development, which protects our natural resources and environment. This document is a stepping stone towards achieving the government vision of seeing Putrajaya and Cyberjaya becoming pioneer green townships in Malaysia as well as towards achieving my pledge made during COP 15.

I hope all stakeholders will find this publication useful and informative as I believe that there has been some extensive research and analysis put into place for the development of this document. It must be noted that the LCCF document is one of the first framework and assessment system produced in the region that highlights exactly how cities can reduce their carbon emission levels. I hope this document will also serve as an important source for overall sustainability towards achieving a better quality of life for our *"rakyat"*.

I would like to record my appreciation to the Ministry of Energy, Green Technology and Water and its partners in producing this beneficial document.

Thank you.

1 Malaysia "People First, Performance Now"

DATO' SRI MOHD NAJIB BIN TUN HJ ABDUL RAZAK
Prime Minister of Malaysia

Message

The Low Carbon Cities Framework and Assessment System or better known as the LCCF is a system developed by my ministry. The purpose of this system is to assist our stakeholders such as developers, local councils, town planners, non-governmental organizations (NGO's) and the public to lower the levels of carbon emission in our cities towards achieving sustainable urban developments.

This system serves as a guide that will propel stakeholders for cities, townships and neighbourhoods to re-assess their priorities in the planning and developing of new projects, as well as strategies that can be taken by existing cities, townships and neighborhoods in reducing their carbon emission levels. Besides serving as a comprehensive guide, the LCCF also has an inbuilt carbon calculator with carbon equivalents that would help stakeholders assess their current baseline levels of the cities, townships and neighbourhood and target their intended levels.

I would like to express my deepest appreciation to the Malaysian Green Technology Corporation, Malaysian Institute of Planners (MIP), Institute Sultan Iskandar (ISI, UTM) and C2C Project Managers for their invaluable support in producing this document. I would also like to commend the editorial team involved in this publication for their dedication and hard work.

I hope the publication of this book will further enlighten all relevant stakeholders on the impending need to mitigate climate change, and the importance of responsible urban development strategies.

DATO' SRI PETER CHIN FAH KUI
Minister of Energy, Green Technology and Water, Malaysia

The Malaysian government is cognizant of the effects of global warming and is committed to addressing this phenomenon. The Prime Minister, Dato' Sri Mohd Najib Bin Tun Haji Abdul Razak, pledged at the *15th United Nations Framework Convention on Climate Change (COP 15)* in Copenhagen that Malaysia will reduce its carbon dioxide emission intensity to 40 per cent per GDP by 2020, as compared to 2005 levels, conditional upon transfer of technology and finance from developed nations.

On 24th July 2009, the government unveiled the National Green Technology Policy (NGTP), which was a turning point in the country's history of initiatives on sustainable growth and development. One of many initiatives is to showcase Putrajaya and Cyberjaya as pioneer green cities.

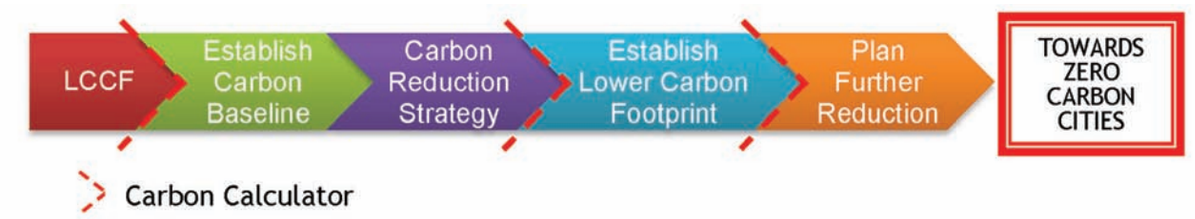
In line with the NGTP, the Low Carbon Cities Framework (LCCF) was initiated to provide a framework to achieve sustainable developments that will subsequently reduce carbon emissions. The document can be used by all stakeholders, in human settlements

of any size, be they cities, townships or neighbourhoods either new or existing, to measure the impact of their development decisions in terms of carbon emissions and abatement. LCCF is a national framework and assessment system to guide and assess the development of cities and to support holistic sustainable development in Malaysia. It will provide for equivalent GHG as a result of human activities in cities so that there may be awareness towards how these GHG can be reduced.

In Part I, the framework introduce and discusses the definition of low carbon cities through the four main focus areas that have carbon impact. The four main focus areas, **urban environment, urban transport, urban infrastructure** and **buildings,** are further sub-divided into 13 performance criteria and 35 sub-criteria.

Part II introduces the carbon assessment and user manual. The assessment system allows the user to calculate the baseline as well as the reduced carbon count. This count will then translate into a carbon reduction rating for any particular development.

LCCF application for cities and developments:



The aspiration of the LCCF is to inspire city managers and developers to participate in the mitigation of global warming and climate change through a real time carbon abatement measure.

CONTENTS

1 INTRODUCTION

1.1 Background of Low Carbon Cities Framework

The Malaysian Government is cognizant of the effects of global warming and is committed to combating this global phenomenon. The nation's commitment was announced to the global community on 17th December 2009 in Copenhagen, Denmark.

In order to reduce carbon footprint in Malaysia, the Prime Minister, YAB Dato' Sri Mohd Najib Bin Tun Haji Abdul Razak, pledged commitment at the 15th United Nations Framework Convention on Climate Change (COP15) 2009 in Copenhagen, Denmark. Malaysia has committed to reduce its carbon dioxide emission intensity to the GDP by 40 per cent per GDP by 2020, as compared to 2005 levels; conditional upon transfer of technology and finance from developed nations.

Prior to COP15, on 24th July 2009, the Malaysian Government unveiled the National Green Technology Policy. This was a turning point in the history of initiatives on sustainable development in Malaysia where a policy focusing on technology, solution and road map to minimising impacts of development on the environment is formulated. The policy, built upon four pillars, namely energy, environment, economy and social aspects, underlines the following five main objectives:-

i. Decreasing growth of energy consumption while enhancing economic development;
ii. Facilitating growth of the green technology industry and enhancing its contribution to the national economy;
iii. Increasing national capability and capacity for innovation in green technology development and enhancing Malaysia's green technology competitiveness in the global arena;
iv. Ensuring sustainable development and conserving the environment for future generations; and
v. Enhancing public education and awareness of green technology and encouraging its widespread use.

The policy also outlines the five (5) strategic thrusts on which the road map for implementation will be concentrated. The success of this policy and its initiatives will be further measured through three sets of sectoral indicators, namely environment, economy and social indicators. One of the indicators under the social perspective is that there "should be more cities, townships and communities in Malaysia embracing green technology and which are classified as green townships".

Whilst green cities or townships have varied definitions and characteristics, more often than not, they have resulted in a definition equivalent to a 'sustainable city'. It makes more sense that a green city would offer long-term sustainability in a holistic manner. Thus the general definition of a green city can be considered to be the same as sustainable city where the characteristics are made up of the three tenets of sustainable development, namely environment, economy and the social perspective.

Many tools have been developed and are readily available to support the development of green city. They include the LEED (Leadership in Energy and Environmental Design by USGBC), Green Mark and Green Star as well as the Malaysian owned Green Building Index (GBI). These tools are largely criteria based tools which accord buildings 'green city' status if they meet the prescribed criteria. However, these rating tools do not measure performance of a building in terms of their impact on the environment and in particular their carbon emission levels.

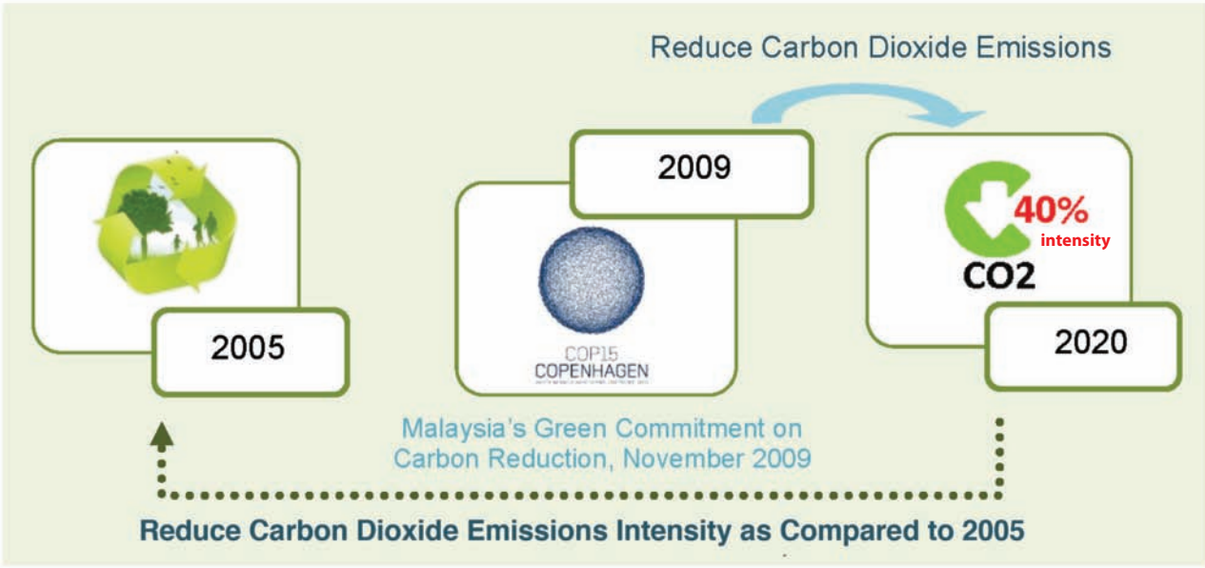
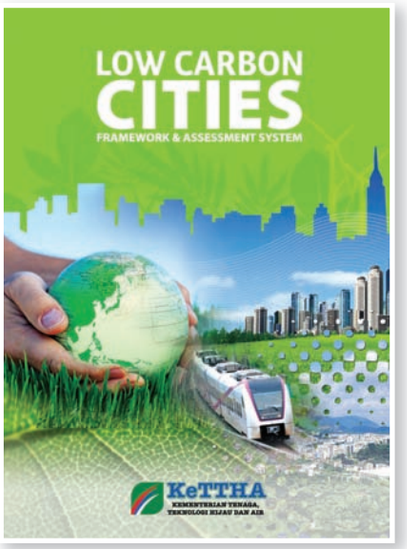


Figure 1.1: COP 15 Commitment by Malaysia

Realising the importance of measuring performance of cities and townships especially their contribution to carbon emission levels of the country and the commitment that Malaysia has made in reducing carbon emission level, the Ministry of Energy, Green Technology and Water (KeTTHA) has embarked on developing a framework for a low carbon city/township that guides the implementation of carbon reduction measures in a city/township. This framework, substantiated by an assessment system, allows for performance of such measures to be quantified and monitored. This Low Carbon City Framework and Assessment System (LCCF) is part of the Ministry's several initiatives for 2010-2011 which aim to set in motion further initiatives and actions at various levels towards reduction in the overall carbon footprint of the country.



The LCCF bridges the gap between existing policies of the government with the many building rating tools currently available in the market *(see Figure 1.2)*. With the government's commitment to carbon footprint reduction, the LCCF helps stakeholders in cities and townships to define their priorities and develop action plans to reduce their carbon emissions as it focuses specifically on strategies and measures towards carbon reduction.

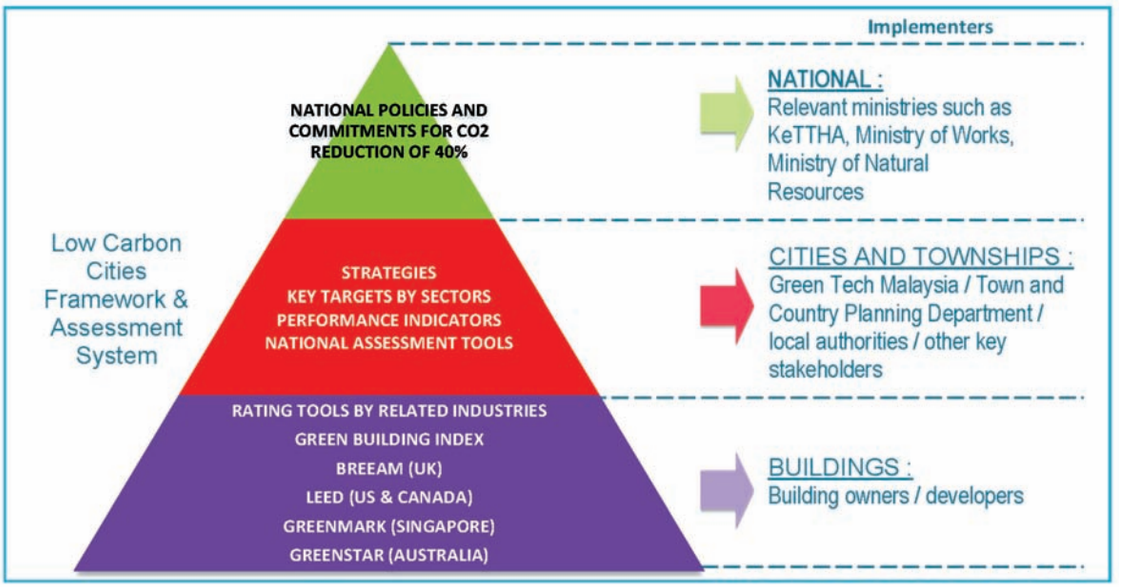


Figure 1.2 : LCCF in Relation to National Policies and Rating Tools

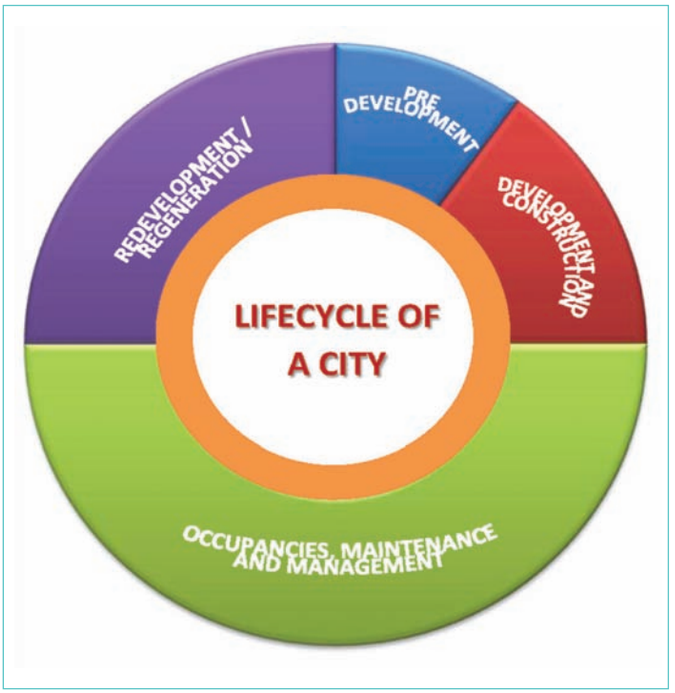


Figure 1.3: Life Cycle of a City

Whilst most criteria based rating tools are developed specifically to aid design of buildings, the LCCF takes into account the birth and ageing of a city or township, and the urban development that is a cyclical process where elements of carbon emission in city activities can result at any stage of a city's lifecycle. The United Nations Environment Programme Sustainable Buildings and Climate Initiative (UNEP-SBCI) reported that 80% of CO_2 emissions occur during the occupancy stage; hence the importance of quantifying city performance at post design and construction stage.

1.2 Purpose and User of Document

This document has been prepared for all stakeholders to provide a framework of the different activities in cities and townships that can contribute to CO_2 emission. The framework will provide for equivalent CO_2 as a result of human activities in cities so that there may be awareness of how the CO_2 can be reduced. In short, this framework aims to:-

i. Create awareness, encourage and promote the concept of green cities in Malaysia, thereby helping to reduce carbon emission in cities and townships;
ii. Guide cities in making choice decisions towards green solutions for their cities and townships;
iii. Allow cities and townships to measure their current and baseline carbon emissions; and
iv. Allow cities and townships to define their carbon strategies and subsequently measure the performance of their action.

This document is intended to be used by all relevant stakeholders that are involved in development, management, maintenance and those providing facilities and services in any cities or townships including local authorities, developers, consultants and other relevant stakeholders involved in the whole development cycle of cities and townships. This document will assist the users to make assessments on whether any part of cities and townships have green practices and can also be used to understand how green townships should be designed or developed. These cities or townships, either existing or new, are low carbon cities which are continuously reducing carbon emission towards ultimately becoming zero or neutral carbon cities.

1.3 A Case for Change

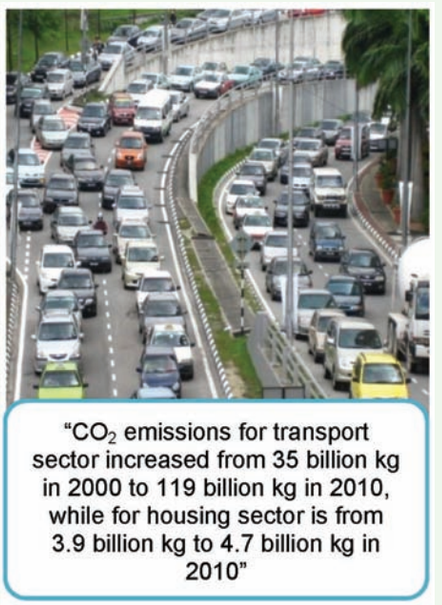
Like most developing countries, Malaysia has experienced very rapid growth in urbanisation. On the national level, the population of Malaysia increased from 18 million in 1990 to 27.6 million in 2010, which is an escalation of 53%. Based on the Department of Statistics (DoS), Malaysia is expected to have a population of about 33.3 million by 2020.

From 27% in 1960 to 42% in 1990, the urbanisation rate continued to grow to 54% in 1994 and 61.8% in 2000. The population in urban areas grew at a rate of 2.2% per annum versus the rural growth rate of 1.6%, over the period of 2000 to 2009. In 2008, the urban population in Peninsular Malaysia reached 67% of the total population, and this is expected to grow to 75% by 2020 as the nation develops. *(Source: Census Data, 2010 & 2001 RFN)*

The above numbers show that more and more people prefer to live in urban areas. Cities have been acknowledged as the engines of growth and cities are where most innovations take place, where consumerism is high. Thus, cities and sustainability are inseparably linked. The high rate of urbanisation in Malaysia implies that cities are also centres where most urban infrastructures are built to cater to the needs of industries, shelter and for recreation and other services.

Cities consume energy, and cities are also centres where environmental degradation and effect of temperature rise can be most felt. Urban development has been widely acknowledged by many to be the main contributor to global warming, contributing 50% of total greenhouse gas emission *(see Figure 1.4)*.

Figure 1.4: Contributors to Green House Gas Emission



"CO_2 emissions for transport sector increased from 35 billion kg in 2000 to 119 billion kg in 2010, while for housing sector is from 3.9 billion kg to 4.7 billion kg in 2010"

According to the Food and Agriculture Organisation (FAO) of the United Nations, Malaysia's annual deforestation rate jumped almost 86% between the 1990-2000 period and 2000-2005. Based on the statistics, Malaysia had lost an average of 140,200 hectares of its forest area per year since 2000. Between 1990 and 2005, Malaysia lost 6.6% of its forest cover, or around 1,486,000 hectares.

Since the mid-1990s, the economy of Peninsular Malaysia has been dominated by the manufacturing industry. The new shift in economic structure initiated rapid urbanisation especially in the Klang Valley, Penang and Johor Bahru. Conversion of agriculture areas into new townships resulted in expansion of urban areas and subsequently, urban sprawls. The emergence of more buildings, particularly in city centres, that were taller and higher, created urban heat island effects that were most felt especially in a tropical climate such as in Malaysia.

With economic prosperity came an increased growth in the number of private vehicles which, in turn, saw the construction of more roads. The number of private vehicles continued to grow in the absence of any other alternative form of transport, especially public transport. According to the Ministry of Transport, Malaysia will have more than 20 million registered vehicles on the road by the year end where more than one million (1,017,361) units of new vehicles were registered in 2009 alone. This means that one in every 30 Malaysians acquired a new motor vehicle every year. As a result, the quality of air has declined due to carbon emission from vehicles.

The volumes of gross domestic product (GDP) and energy demand (or CO_2 emissions) have direct co-relation, since economic growth increases use of energy whose major source is fossil fuel. Between 2008 and 2030, global primary energy consumption is expected to rise by 1.6% per annum or 45% in total in the next 21 years. Here in Malaysia, electricity demand is forecasted to reach 18,947 megawatts (MW) in 2020 and 23,092 megawatts (MW) in 2030. This is an increase of almost 35% from the 14,007 megawatts (MW) figure in 2008.

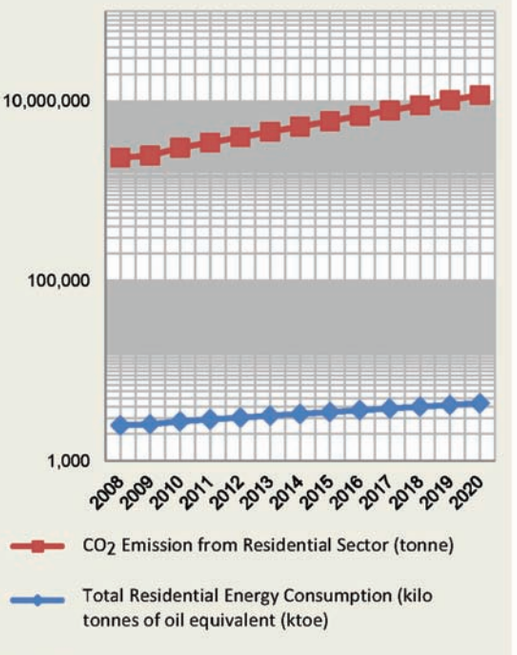
The Carbon Dioxide Information Analysis Centre (CDIAC) ranked Malaysia in 58th place of CO_2 emission per capita per year per country in 2007. This measurement considered only carbon dioxide emissions from the burning of fossil fuels and cement manufacturing but not CO_2 emissions from land use change and deforestation. Based on the statistics, Malaysia emitted 7.3 metric tons of CO_2 per capita in 2007. In this regard, Malaysia had an increase of 135.48% which was from 3.1 to 7.3 metric tons of CO_2 per capita from 1990 to 2007.

Greenhouse gas emissions in Malaysia increased substantially by 13% and 32% per GDP and per capita respectively between 1994 and 2000. The total greenhouse gas emissions increased by 45% in 2000 when compared with the 1994 levels. Malaysia's emission of CO_2 per capita which was about 7.1 tonnes/capita was higher than the average for Asia Pacific of 2.6 tonnes/capita based on the National Communications Report submitted by each country to the United Nations Framework Convention on Climate Change (UNFCCC).

Based on the research from Universiti Kebangsaan Malaysia (UKM), the CO_2 emission in 2008 was an estimated 2,347,538 tonnes and this is expected to increase up to 11,689,308 tonnes by 2020. This estimation is measured by the business as usual (BAU) situation and the assumption factors based on residential energy consumption alone which includes the four types of energy, namely natural gas, liquid petroleum gas (LPG), kerosene and electricity *(see Figure 1.5)*.

Recent environmental awareness amongst the general public has resulted in many campaigns for environment and climate change. These have provided the background for the evolution of policy response to environmental change in Malaysia.

Year	Total Residential Energy Consumption (Ktoe)	CO_2 Emission from Residential Sector (tonne)
2008	2,495	2,347,538
2009	2,568	2,477,865
2010	2,761	3,034,690
2011	2,899	3,462,953
2012	3,042	3,965,759
2013	3,191	4,550,769
2014	3,346	5,226,110
2015	3,506	6,000,380
2016	3,673	6,882,644
2017	3,845	7,882,433
2018	4,023	9,009,749
2019	4,207	10,275,062
2020	4,397	11,689,308



Source: Institute for Environment and Development (LESTARI), 2008

Figure 1.5: Future Trend of Total Residential Energy Consumption and CO_2 Emission

1.4 Malaysia's Efforts towards Sustainable Development and Climate Change Agenda

Ever since the United Nations Conference on the Human Environment in 1972, Malaysia has been serious in dealing with environmental issues. In 1992, Malaysia showed its commitment on the Rio Summit after which the Malaysian National Environmental Policy was established. The policy became the basis for the country to give attention to environmental issues. The figure below represents Malaysia's sequence of actions and involvements since 1972.

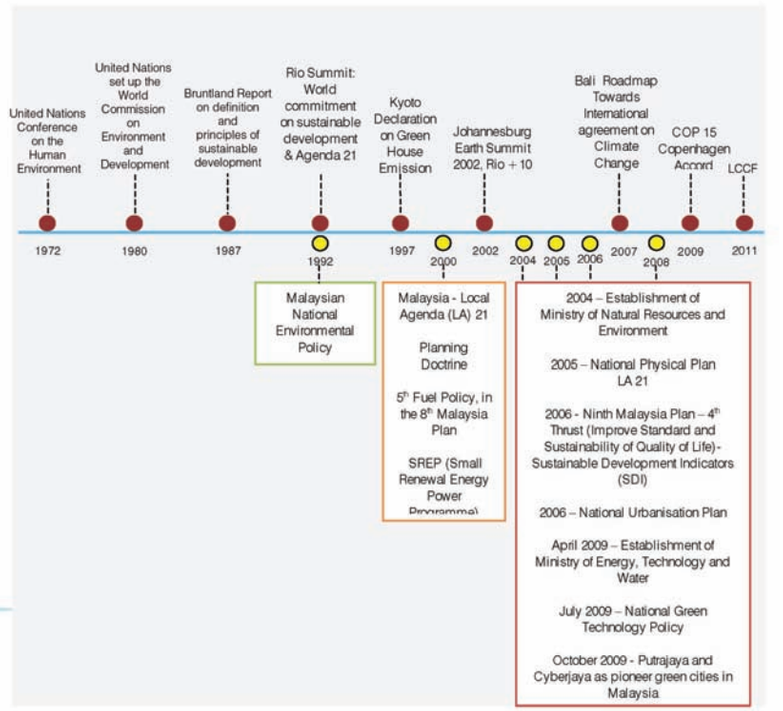


Figure 1.6: Malaysia's Involvements in Sustainability Development Agenda since 1972

In 1992-2009, efforts were made to integrate sustainable policies into development plans. As a result, many of the environment protection strategies have been incorporated through structure plans, local plans and other development plans. These plans will then be implemented by government agencies including local authorities. Efforts for sustainable development were further emphasised in the Sixth Malaysia Plan, which incorporated environmental and sustainable development directions into economic growth programmes. This was continued into the Seventh Malaysia Plan (1996–2000). Although the goals of sustainability and the policy integration were formulated, it was not until the Eighth Malaysia Plan (2001 to 2005) that practical efforts were put into effect.

In 2005, the National Physical Plan (NPP) established a spatial framework for the general direction of physical development for the nation. This important national framework formed the basis on which lower tier development plans (structure plans, local plans, special area plans and other sectoral plans such as transport and rural development plans) were formulated. The NPP ensured that these development plans conform to a cohesive set of national objectives and policies. The spatial framework was to ensure that national resources would be optimally used, duplication in infrastructure investment avoided, and more sustainable development in the states achieved. The National Physical Plan has been put into practice to serve as the framework to achieve integrated and sustainable land use planning in the country and this framework will be adopted by other development plans at state and local levels.

Recently, the Federal Department of Town and Country Planning (FDTCP) prepared a Green Neighbourhood Planning Guideline (GNG) as a planning manual for design and development of a green neighbourhood. This Green Neighbourhood Planning Guideline aims to provide the basis for state governments to formulate policies and the mechanism to encourage more green neighbourhoods, for local authorities to provide the framework in appraising development applications for planning permissions and for developers in designing their development proposals. The LCCF and GNG are complementary each other towards holistic sustainable development in the country.

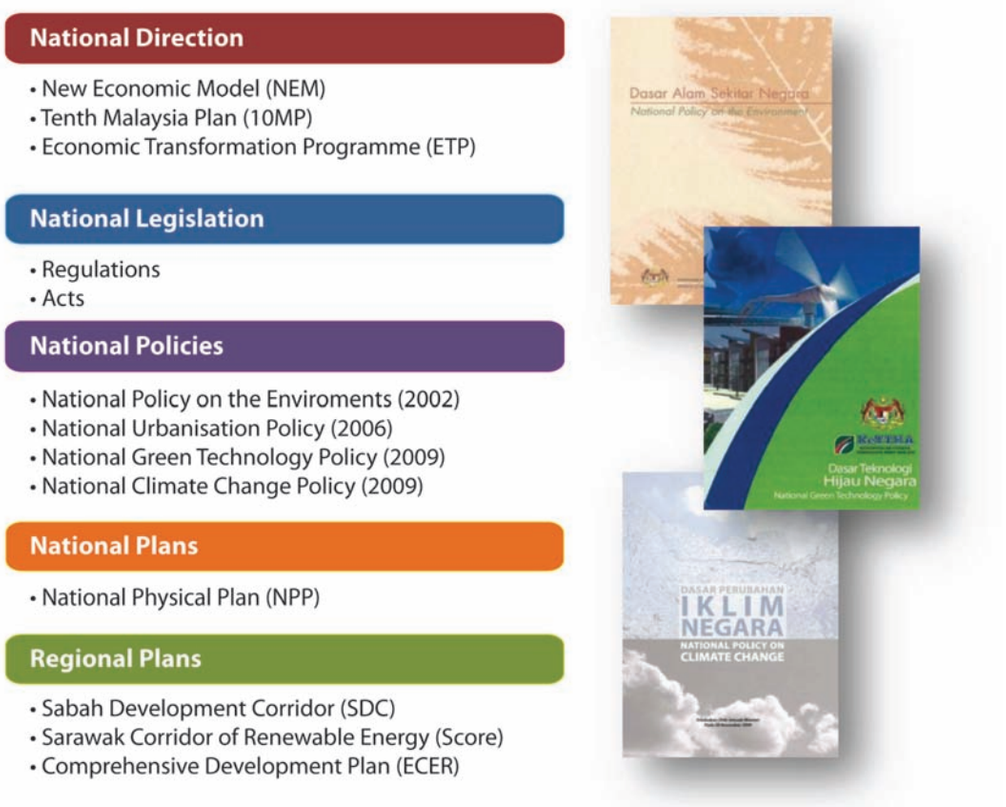


Figure 1.7: Hierarchy of Framework for Sustainable Development

Figure 1.8: Design Criteria for a Green Neighbourhood in FDTCP's Green Neighbourhood Planning Guideline
Source: Green Neighbourhood Planning Guideline, FDTCP

1.5 Concept and Brief Overview of Greenhouse Gases (GHG) / Carbon Dioxide (CO_2)

The earth's surface needs to retain some of the sun's heat in order to regulate mean global temperatures, and naturally occurring gases in our atmosphere such as the ozone, water vapour, methane, nitrous oxide and carbon dioxide serve this purpose by trapping the required amount of heat from the sun so that conditions are conducive to the survival of all living creatures.

However, with the advent of the age of industrialisation in the late 1700s, man-made activities have accelerated the increased presence of some of these naturally occurring gases as well as other man-made gases in our atmosphere. Simplistically put, these gases as well as other man-made gases *(see Table 1.1)* increase the amount of the sun's trapped heat when allowed into our atmosphere and cause global warming and climate change.

The United Nations through the efforts of the UNFCCC has established the role of six gases that contribute to the advent of global warming and climate change with their increased presence in our atmosphere.

Table 1.1: Types of gases in atmosphere

No	Name of Gas	Chemical Formula	GWP (over 100 years)	Atmospheric Life Span (years)
1.	Carbon dioxide	CO_2	1	100-1000
2.	Methane	CH_4	23	12
3.	Nitrous oxide	N_2O	296	114
4.	Chlorofluorocarbons	CFCs (various)	6000 - 14000	45-1700
5.	Hydro fluorocarbons	HFCs (various)	12 - 1200	0.3-260
6.	HFCs (various)	SF_6	22000	3200

Of these six gases, CO_2 is the largest and the most commonly referred to in relation to climate change although the other gasses have a greater impact on climate change when compared to CO_2 in equal volumes. As an example, one ton of methane is 23 times more potent than one ton of CO_2. However, CO_2 has been selected as the benchmark measure gas and has the global warming potential of 1 compared to that of methane which is 23.

The resultant increased heat gain causes climate change due to the fact that there is a fine balance between global mean temperatures and pressures which is disturbed because of the additional heat trapped by the earth. Even a slight change in temperature and / or pressure can cause seasonal climates to behave erratically. We experience this nowadays all over the world and there has been a growing intensity as well as frequency of natural disasters that in turn can give rise to connected disasters.

Collectively the six gases are called 'greenhouse gases (GHGs)' and the GWP is the potential of each gas to trap heat over a given period of time (see diagram below).The increased volume of the six gases will also result in the increased mass and density of the atmosphere which in turn will trap some of the sun's heat. This heat will build up over time and cause a rise in global mean average temperatures.

Global temperature records show that since the start of the industrial age, the temperature of the earth has not risen so rapidly compared to any given 100-year block of recorded history, since the start of recorded history era to date. Carbon dating of the ice columns drilled out of the polar caps also gives support to this evidence by tracing history back to a few million years.

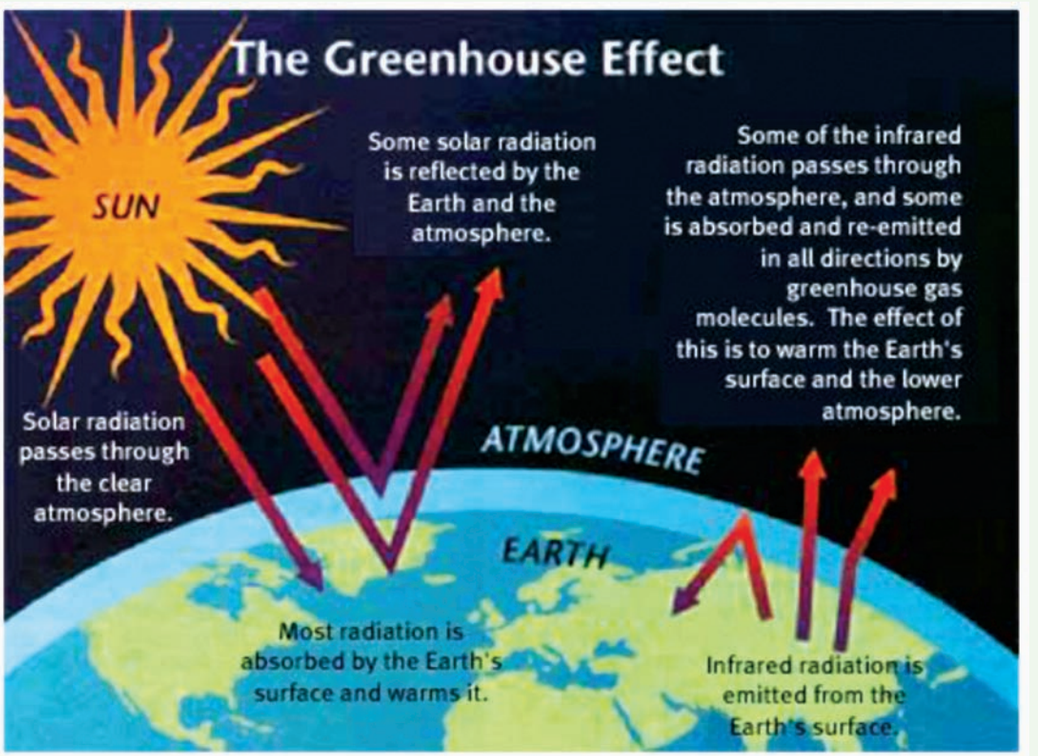


Figure 1.9: The Greenhouse Effect
Source: www.arcticportal.org/greenhouse-gases

2 LOW CARBON CITIES FRAMEWORK

2.1 Definition of Low Carbon Cities

The concept of 'low carbon cities' (LCCs) is currently gaining momentum in the urban development and urban governance scene as cities come to terms that global warming and climate change are the result of urbanisation, population rise and economic growth, and that the most significant increase of energy consumption and CO_2 emissions takes place in cities and urban areas.

Unlike sustainable development, there have not been any standard definitions of LCCs. The definition of a LCC more often than not results in the equivalent of a 'sustainable city'. One worldwide definition of sustainable city illustrates apparent association to CO_2 emissions and other elements contributing to climate change by defining a sustainable city as "a city designed with consideration of environmental impact, inhabited by people dedicated to minimisation of required inputs of energy, water and food, and waste output of heat, air pollution – CO_2, methane and water pollution".

Low Carbon City can be defined as a city that comprises of societies that consume sustainable green technology, green practices and emit relatively low carbon or GHG as compared with present day practice to avoid the adverse impacts on climate change.

According to the Chinese Research Academy of Environmental Sciences, a low carbon city leads to low carbon economics and society along with a sustainable form of development. There are two aspects in a low carbon city conception, namely:-

- ***Low carbon economics***
  To increase energy, water efficiency and reduce carbon emission based on efficiency in use of resources and green technology.

- ***Low carbon consumption***
  To reduce carbon emission from all aspects of city living which include recycling, protecting the natural environment, maintaining green areas in the city and increasing carbon sink.

The concept of LCCs is closely aligned with sustainable development. Through the adoption of the principle of sustainability, carbon emissions can be reduced through the means and ways in which cities are designed and developed, and the ways resources are consumed. Essentially, LCCs are cities that take serious and effective action to reduce their environmental impact and their CO_2 emissions.

LCCs demonstrate high energy efficiency, power themselves with renewable sources of energy, produce the lowest quantity of pollution possible, use land efficiently; compost used materials, recycle them or convert waste to energy. Essentially, LCCs are cities that adopt and embed the principles of sustainable development to contribute minimally to climate change.

2.2 Sustainable Framework for Low Carbon Cities

Sustainable cities are characterized as cities where people want to live now and in the future, where the cities meet the diverse needs of existing and future populations, are sensitive to their environment and ensure that their lifestyle and consumptions do not adversely affect the environment, preserve their natural ecology and contribute to a high quality of life. Sustainable cities are safe, inclusive, well planned, built and managed and offer equality of opportunities and good urban services for all.

All the above characteristics can be grouped into eight elements, the combination of which performs like a complete eco-system for sustainable cities (Figure 2.1). The sustainable city elements address the three tenets of sustainable development, namely economic, social and environmental.

Figure 2.1: Elements of Sustainable Cities

2. LOW CARBON CITIES FRAMEWORK

As low carbon cities essentially are a sub-set of sustainable cities, the development of the LCCF has been formulated to provide a framework and tool for further implementation of the whole spectrum of strategic and policy development on sustainability within the Malaysian context; with specific focus on tracking carbon emissions at city levels. In the long term, the LCCF will help to further update the status of improvement made on carbon emission components of sustainable cities.

Many communities use livability indices to monitor and communicate their progress in the achievement of particular social, economic, and environmental goals for a particular geographical area. Within Malaysian context, the Federal Town and Country Planning Department has successfully developed a sustainable development indicator known as Malaysian Urban Indicators Network (MURNInet). MURNInet determines the level of sustainability of each town in Malaysia using Malaysian Urban Indicators based on 11 planning components. The components are demography, housing, economy, infrastructure and utilities, public facilities, sociology and social impact, land use, tourism and heritage, transportation and accessibility, and management and finance.

The development of the indicators used in MURNInet was aimed to tackle issues and targeted to measure policies and programmes at the time it was first formulated in year 2002. However, due to changing circumstances with new emerging sustainable development issues and the government's future policies and strategies especially which focus on the recently announced Government Transformation Programme (GTP), New Economic Model (NEM), National Physical Plan, National Urbanisation Policy (NUP), National Green Technology Policy, National Policy on Climate Change, and Tenth Malaysia Plan, MURNInet has been reviewed to ensure that the indicators are relevant to measure the performance of cities towards achieving sustainable development policies and strategies.

The review has commenced in February 2011 where indicators of sustainable development are grouped within the framework of 6 dimensions and 26 themes. The dimensions are Competitive Economy, Sustainable Environmental Quality, Sustainable Community, Optimal Land Use and Natural Resources, Infrastructure and Transport Efficiency, and Good Governance. A cross-sectoral approach has been adopted in deriving at the sustainable index for evaluating cities performance on sustainable development. Some of the indicators identified are either directly or indirectly will contribute towards reducing carbon emission reduction objective of the country as well as the current concern of climate change and global warming.

The development of LCCF is a complementary tool of MURNInet which provide more detail assessment on carbon reduction. The associated assessment tool enables this whole livability assessment to be further enhanced in order to gauge the real performance of cities in Malaysia, where subsequently real and measurable actions can be initiated and implemented to achieve the national policy and commitment for 40% carbon reduction by 2020.

Figure 2.2 illustrates the relationship of the carbon emission performance based assessment tool provided by the LCCF within the whole framework for sustainable development in Malaysia.

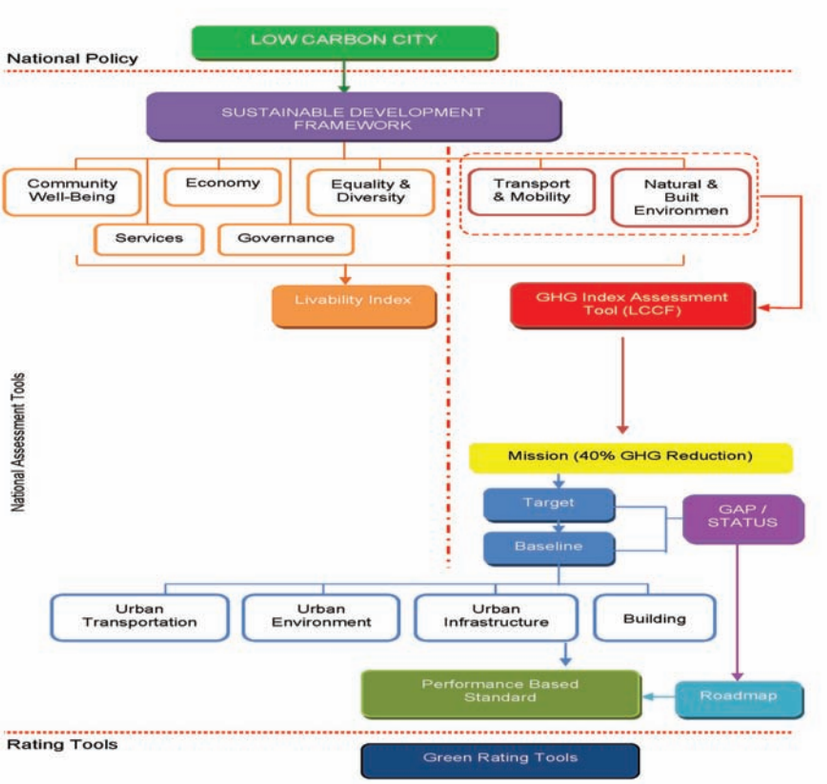


Figure 2.2: Sustainable Framework for Low Carbon Cities

3 KEY FEATURES OF LCCF

3. KEY FEATURES OF LCCF

3.1 Performance Based System

The LCCF provides a framework for the LCCF Calculator. It is a performance based system which captures the actual environmental impact of a development in terms of total carbon emissions. This measure is carried out through:

1. The construction stage;
2. The embodied carbon contained in the cities constructed form; and
3. The operational carbon emissions during the life span of the cities.

It gives priority to performance criteria which have significant impacts on the environment and ensure that this priority is undertaken to reflect the targeted goal.

This performance based assessment system prioritises performance based benchmarks to ensure total environmental impacts in terms of carbon emissions are measured and reduced.

Existing rating systems such as LEED (by USGBC), GREENMARK (Singapore), GREENSTAR (Australia), BREEAM (UK) and GBI (Malaysia) are 'criteria based' as compared to the LCCF which is 'performance based'.

'Criteria based' systems encourage 'point chasing' rather than activities that result in measured environmental impact which is achieved by 'performance based' criteria, where a year on year abatement can be tangibly achieved. Also, 'criteria based' systems may have a periodic review (of 3 years, in some cases) but environmental impacts in between review periods go unchecked.

3.2 Elements That Contribute to GHG Emissions

This document is designed to contribute to the Prime Minister's commitment at COP 15 in Copenhagen in December 2009: conditional voluntary target to reduce emission intensity of up to 40 per cent of gross domestic product compared to 2005 levels.

A 'GHG reduction' approach is used in this document. The carbon equivalents of each activity producing GHGs are focused on four identified elements: urban environment, urban transport, urban infrastructure and building (see figure 3.1).

These elements are further categorised into 13 performance criteria and 35 sub-criteria, each of which provides specific intents towards carbon reduction targets. Chapter 4 of this document elaborates in further detail the elements and performance criteria.

Figure 3.2 shows a summary of the performance criteria and sub-criteria. The four main elements are further segregated into 13 performance criteria and 35 sub-criteria.

3.3 Approaches for Assessments

Different cities face different issues and challenges. This being the case, each city should then be ranked according to its own demographics and attributes. Cities need to identify and list out the key element that they want to measure and determine the areas of concern and territory boundaries. It is essential for cities to recognise and understand which elements are the major contributors of the cities' GHG emissions. Once the elements have been identified, they have a choice between:

1. City Based Approach
- mitigating all the criteria as stated within the LCCF; or

2. One-System Approach
- mitigating one criterion or not all the criteria in the LCCF.

For a city based approach, a holistic view is taken. All criteria are considered and mitigated. A step by step process to address each of the four main criteria is conducted. Each of the 35 sub-criteria is considered in detail. The final outcome will be to derive a complete baseline and subsequently to develop a reduced carbon footprint from this baseline then implement the same within the entire development.

Curitiba, Brazil and Stockholm, Sweden are some examples of such cities that have applied the holistic city based approach (refer to the website *www.worldbank.org/eco2*).

The one-system approach on the other hand is applied when the decision is made to proceed with an exercise towards a low carbon city but only in particular selected sectors as described in the main criteria, as a start and to establish a road map towards a holistic or city based approach.

Although this approach has less impact, nevertheless it is a start and over time may be converted into a holistic approach.

Yokohama in Japan is an example of such a city (refer to the website *www.worldbank.org/eco2*).

Figure 3.1: Four Main Identified Elements in LCCF

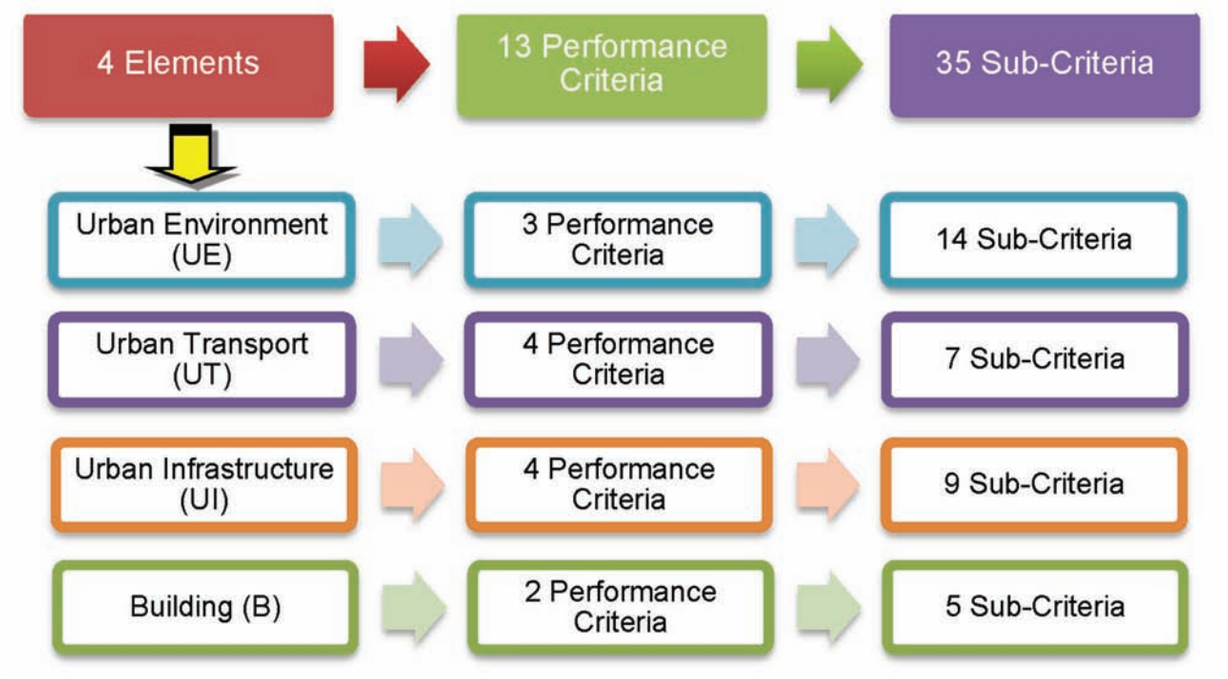


Figure 3.2: Summary of Elements, Performance Criteria and Sub-Criteria

3.4 Application of LCCF

As introduced in Chapter 1, there are two groups of users of this LCCF document which are the local authorities and stakeholders of the city or town. The following points will detail out the application of the LCCF with regard to the two different user groups.

3.4.1 Local Authority Level

Local authorities will play a major role in undertaking policy initiatives on lowering carbon emissions of the city. The following diagram shows the application of the LCCF at the local authority level:

Figure 3.3: Local Authority Level

Step 1 - Mobilise City Stakeholders

At this early stage, local authorities need to identify potential stakeholders for the plan within a city context such as NGOs, institutions and the local community.

From that, local authorities should take the initiative to form an effective taskforce for a city-wide carbon reduction plan or the one-system approach which shall include people or groups like the project leader, sponsors, project members and councils.

After setting up a core team, local authorities may establish the city's vision and target that need to be achieved by preparing a road map for implementation of a carbon reduction assessment using the LCCF and LCCF Calculator (see Appendix 1 on Guide to Setting a Road Map).

Step 2 - Emission Baselines and Opportunities

For the next step, local authorities shall create the baseline according to the following procedure:

i. Decide jurisdiction boundaries;
ii. Identify CO_2 emission sources;
iii. Decide base year(s);
iv. Compile data for base year(s); and
v. Estimate emissions and quality assurance data.

Step 3 - Develop City Strategy

Once the project and baseline have been identified, it is important then to finalise the city target in carbon reduction. The 'what' and 'how' of the carbon reduction programme need to be explained together with strategies and programmes for implementation.

Step 4 - Implement and Review

The final stage at this local authority level is to launch a city strategy. The Carbon Reduction Management Plan or Green City Action Plan should be legally enforceable before any public launch.

Such a project should be undertaken by the taskforce responsible for the delivery of specified projects as stated in the Carbon Reduction Management Plan or Green City Action Plan.

Once the project is underway, the taskforce needs to collect data that is needed on an annual basis. The purpose is to update the emission inventory. The information should then be fed into the plan to assess whether the city is on track to meet any targets set. Monitoring progress and communicating success are crucial to maintain enthusiasm and support amongst stakeholders.

3.4.2 Stakeholder Level

Besides local authorities, stakeholders also play an important role in lowering carbon emissions of a city. Stakeholders can be developers, town planners or designers. The following diagram shows the application of the LCCF at stakeholder level:

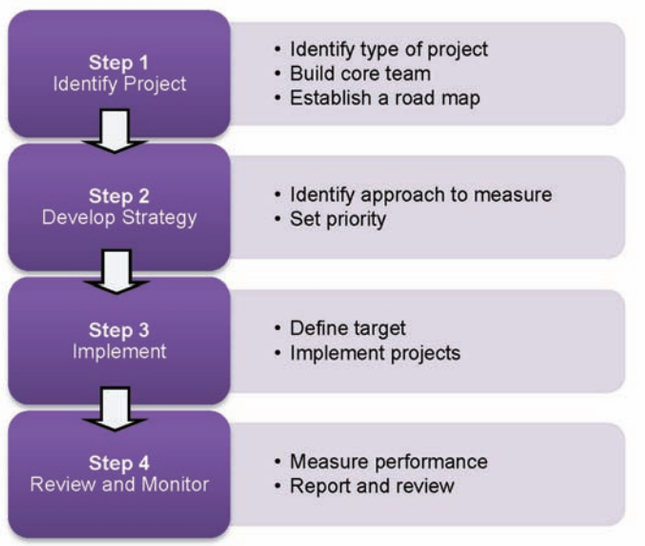


Figure 3.4: Stakeholder Level

Step 1 - Identify Project

Stakeholders need to identify the type of project that they intend to develop. They then need to establish a working group for the identified project and identify the roles and responsibilities of each member. The team needs to work together with the aim of looking into all aspects to achieve a low carbon city. However, before they can embark on the project, they need to create a road map with the aim to achieve a low carbon city. It is important to have a road map as it can be a useful tool where it allows a focused start to the journey to achieve a specific goal.

Step 2 - Develop Strategy

The next step is to establish a baseline based on 'Business as Usual' (BAU). This step consists of establishing the carbon footprint based on an implementation plan where no carbon reduction plan is considered.

On completion of this stage and having a baseline, it is then possible to embark on a carbon reduction plan and strategy. This plan will automatically be able to derive the amount of emission abatement possible when the plan is successfully implemented.

Step 3 - Implement

At the implementation stage, the plan and strategy must be carefully adhered to. This will result in minimal slippage from the original intent. During the entire implementation process, improvements in the abatement plan can also be introduced provided these improvements do not negatively impact the schedule and budget of the project.

Step 4 - Review and Monitor

On completion of the project and upon commissioning of all systems, the performance of the project can start to be measured periodically. The team can choose to measure the performance based on its specific timeline, whether every six months, yearly, etc. Monitoring is important to ensure that the projected carbon emissions are achieved, if not, why and the team must work together to identify the deficiencies. If it achieves the target, the team can plan for further reduction in the next phase of development as planned in the road map.

3.5 Relationship between Framework and Calculator

Besides local authorities, stakeholders also play an important role in lowering carbon emissions of a city. Stakeholders can be developers, town planners or designers. The following diagram shows the application of the LCCF at stakeholder level:

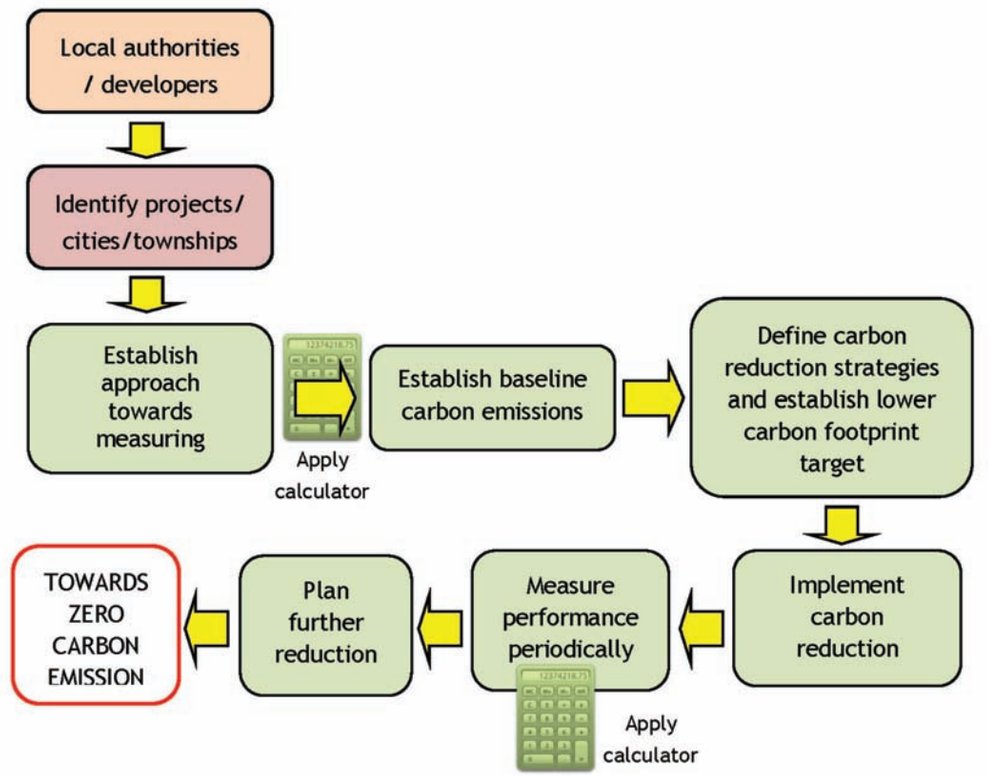


Figure 3.5: Process and Procedure Application of LCCF

Reduction performance of a particular city, either through the city based approach or one-system approach, will be awarded an environmental performance rating as shown in Figure 3.6.

Carbon Reduction Level	Level of Achievement
100	Carbon Neutral
70 - 99%	Best Practice 5
50 - 69%	Best Practice 4
30 - 49%	Best Practice 3
10 - 29%	Best Practice 2
1 - 9%	Best Practice1

Figure 3.6: Environmental Performance Rating

4 PARAMETERS FOR LOW CARBON CITIES

4.1 Introduction

The performance criteria for low carbon cities are measurable strategies to reduce carbon emission through policy control, better process and product management, development of technology, transformation in procurement system, consumption strategies, carbon capture and others. In relation to this, the identification of key elements that contribute to city carbon emission is fundamental. This is because a city needs to recognise and determine the areas of concern and territory boundaries in order to measure the performance of its efforts to lower carbon emission.

The key elements identified, which are urban environment, urban transport, urban infrastructure and buildings, and the further 13 performance criteria and 35 sub-criteria help the stakeholders to comprehend the cities' carbon footprint and at the same time assist them in taking the applicable reduction measures in achieving the national climate aspirations.

As different cities face diverse concerns and challenges, each city must prioritise based on its own essentials and capabilities.

Figure 4.1: Breakdown of Performance Criteria and Sub-Criteria

Table 4.1: List of Performance Criteria and Sub-Criteria
Urban Environment

UE 1	Site Selection	Page No.
1-1	Development within Defined Urban Footprint	21
1-2	Infill Development	22
1-3	Development within Transit Nodes and Corridor	23
1-4	Brownfield and Greyfield Redevelopment	24
1-5	Hill Slope Development	25
UE 2	**Urban Form**	**Page No.**
2-1	Mixed-Use Development	26
2-2	Compact Development	27
2-3	Road and Parking	28
2-4	Comprehensive Pedestrian Network	29
2-5	Comprehensive Cycling Network	30
2-6	Urban Heat Island (UHI) Effect	31
UE 3	**Urban Greenery and Environmental Quality**	**Page No.**
3-1	Preserve Natural Ecology, Water Body and Biodiversity	32
3-2	Green Open Space	33
3-3	Number of Trees	34

4. PARAMETERS FOR LOW CARBON CITIES

Urban Transport

Urban Infrastructure

Building

4.2 Performance Criteria

URBAN ENVIRONMENT	
Performance Criteria **SITE SELECTION**	
UE 1-1	**Development within Defined Urban Footprint**

Intent

Prioritise development within the defined urban footprint by designating the area inside the boundary for urban development.

Description

Urban footprint refers to established urban areas which are generally being served by urban services in particular infrastructures and utilities. They include residential (including urban villages), commercial, industrial, open space, community facilities, transport, infrastructures, land already committed/approved for development and vacant land.

Urban footprint forms a set geographical boundary for a city or township in an attempt to manage urban growth and control urban sprawl. Prioritising development within the urban footprint compared to selecting a development site outside the urban footprint will reduce travel to the city centre where daily commuting is required. The further the travel, the higher it contributes to CO_2 emission. Developing within the urban footprint will also limit the clearing of a forest reserve and large plantation areas, as this will reduce the release of CO_2 into the atmosphere.

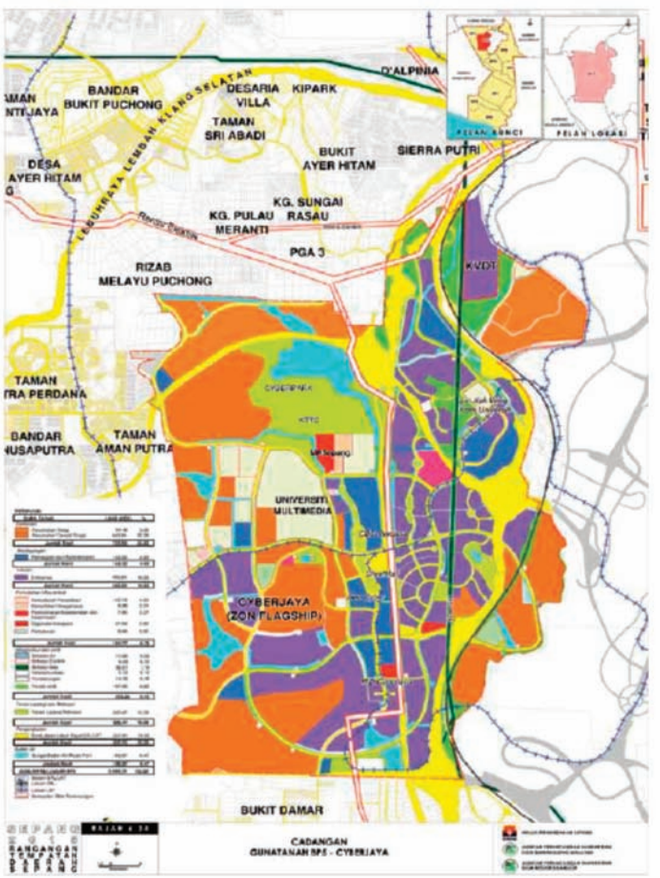
Development is discouraged outside the defined urban footprint boundary and it can be a direction for the authority to make decisions for zoning and land use planning.

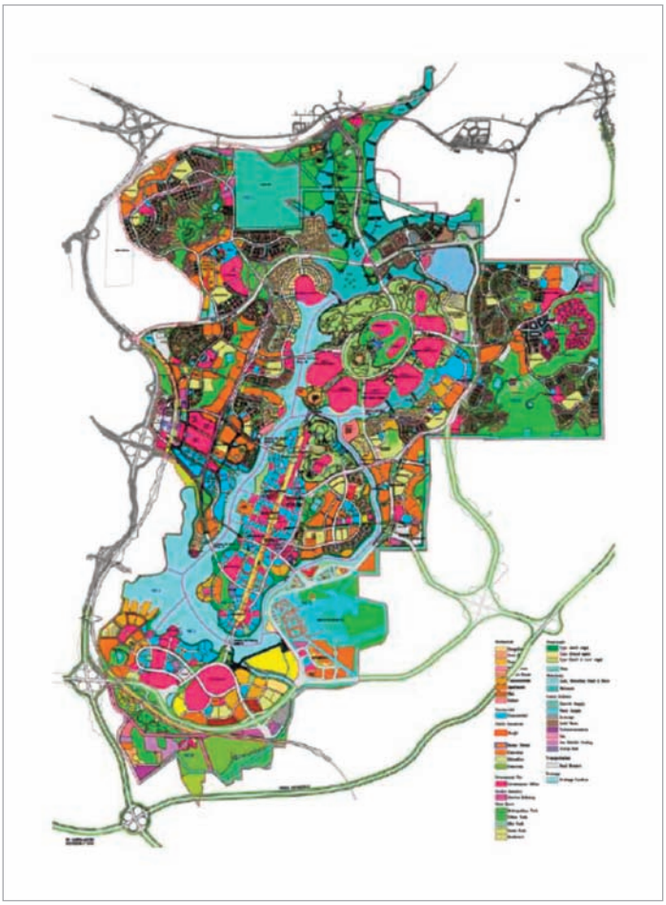
Carbon Emission Reference

1. 1 km travel by car (petrol) emits 0.26 kg of CO_2.
2. 1 hectare of tropical forest captures 4.3 tCO_2/year to 6.5 tCO_2.
3. 1 acre of developed Greenfield area emits 10,000 kg of CO_2.
   (Source: redevelopmenteconomics.com)

Recommendations for Carbon Emission Reduction

1. Land use planning policy in development plans to:-
   - Define urban footprint;
   - Encourage infill developments; and
   - Minimise agricultural land conversion.





4. PARAMETERS FOR LOW CARBON CITIES

URBAN ENVIRONMENT

Performance Criteria
SITE SELECTION

UE 1-2	Infill Development

Intent
Encourage development within and near existing communities and public transit infrastructure.

Description
According to the National Urbanisation Policy, infill development is defined as development or redevelopment being implemented on vacant land or a developed site located in a built area as well as areas currently being developed.

Selecting infill sites for development will directly reduce CO_2 emission from earthwork activities and infrastructure development. Infill developments are normally located within matured development and this will reduce the need for major earthwork. Infill development has a significant economic benefit in reduction or elimination of new infrastructure, including new roads, utility services and other amenities. The redevelopment of urban areas helps restore, invigorate and sustain established urban living patterns, creating a more stable and interactive community.

Currently, many development plans in Malaysia have identified infill development as one of the key development strategies to overcome urban sprawl. This strategy has been gazetted as a development policy under development plans such as the National Physical Plan, 2025 Comprehensive Development Plan in Iskandar Malaysia, Pahang Structure Plan, 2006, Selangor Structure Plan, Penang Structure Plan and Johor Bahru Local Plan.

Carbon Emission Reference
1. 1 km travel by car (petrol) emits 0.26 kg of CO_2.
2. 1 acre of development in infill and brownfield area emits 7,000 kg of CO_2 emission (savings of 3,000 kg of CO_2 compared to greenfield development)
   (Source: Congressional Research Service, 2009)

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Incorporate sustainable infill land use in planning and policy initiatives.
2. Locate the project on a site served by public transit infrastructure, existing water and wastewater infrastructure.
4. Identify infill sites and zoning plans.
5. Provide incentives for infill projects.

URBAN ENVIRONMENT	
Performance Criteria **SITE SELECTION**	
UE 1-3	**Development within Transit Nodes and Corridors**

Intent

Reduce energy consumption and mobility of private vehicles by prioritising development within existing public transport corridor.

Description

Transit nodes and corridors generally refer to public transport services such as rail transit station and bus rapid transit (BRT) station. They are located in a radius of 400 m to 800 m from public transit stops. These locations are designed to encourage public transport use, transit ridership, mixed-use development and pedestrian networks which will reduce the amount of parking spaces and private vehicle use. Development should be encouraged within transit nodes and corridors as this concept relies on the integration between land use and transport system. Thus, it will reduce the CO_2 emissions contributed by private vehicle use.

Development within transit nodes and corridors will revitalise neighbourhoods, increase social interaction, pedestrian and transit-oriented development (TOD). TOD is designed to maximise access to public transport and emphasise the smart growth development strategy which has currently been promoted by many development plans in Malaysia.

Carbon Emission Reference

1. 1 km travel by car (petrol) emits 0.26 kg of CO_2.

Recommendations for Carbon Emission Reduction

Local authorities and other related agencies should take the following actions:-

1. Prioritise development within transit nodes and corridors in development plans.
2. Intensify development within transit nodes and corridors.
3. Locate a project within 400 m walking distance of bus rapid transit and/or streetcar stops, light or heavy rail stations, and/or other public transport, e.g. ferry terminals.
4. Provide locational incentives for development within transit nodes and corridors (e.g. parking charge reduction).

URBAN ENVIRONMENT	
Performance Criteria **SITE SELECTION**	
UE 1-4	**Brownfield and Greyfield Redevelopment**

Intent

Prioritise and encourage redevelopment of land in Brownfield and Greyfield areas.

Description

Brownfields are industrial and commercial properties suspected to be environmentally contaminated. *(Source: Camden County Improvement Authority)*

Greyfields are properties in urban and older suburban communities that have been under-utilised or abandoned such as a closed shopping strip mall. These properties do not have environmental issues preventing reuse and expansion.*(Source: Camden County Improvement Authority)*

Brownfield and Greyfield sites are mostly located within urban footprints. Therefore, prioritising redevelopment at these sites will reduce vehicle trips and discourage urban expansion, which lead to reduction in CO_2 emissions.

The idea of brownfield and Greyfield was actually to optimise use of space within the cities. Since the issue of land availability has become a prime concern, brownfield and Greyfield redevelopment helps to resolve the scarcity of land whilst improving the social and economic issues of the place.

Brownfield and Greyfield redevelopment reduces pressure on undeveloped land. Using existing infrastructure and on-site materials as resources can help reduce project costs for new materials. The rehabilitation of a site with environmental contamination is an opportunity to improve the environmental quality and resources available to local communities.

Carbon Emission Reference

1. 1 km travel by car (petrol) emits 0.26 kg of CO_2.
2. 1 acre of development in infill and brownfield area emits 7,000 kg of CO_2 (savings of 3,000 kg of CO_2 compared to greenfield development) *(Source: Congressional Research Service, 2009)*

Recommendations for Carbon Emission Reduction

Local authorities and other related agencies should take the following actions:-

1. Incorporate sustainable Brownfield or Greyfield in planning and policy initiatives.
2. Locate a project on a site served by existing water and wastewater infrastructure.
3. Provide incentives for Brownfield and Greyfield developments.

URBAN ENVIRONMENT

Performance Criteria
SITE SELECTION

UE 1-5	Hill Slope Development

Intent
Protect hill slopes to minimise erosion and reduce environment impacts from hill slope development.

Description
Besides floods, Malaysia also faces soil erosion issues. High rainfall, steep slopes and soil structure are factors that contribute to soil erosion. Hence, it is important to maintain the greenery and vegetation as soil cover to control erosion as well as to maintain the natural landscape.

Hill slopes have minimal impact with respect to GHG emission reduction. However, long-term planning is needed to increase the resilience of resources, natural system and infrastructure to climate change. Protecting hill slopes also directly protects the natural environment and preserves greenfield.

Hill slope developments need to be managed in a sustainable manner and be strictly controlled to protect the environment and safety of city dwellers.

Carbon Emission Reference
1. 1 tropical tree forest absorbs 5.5 kg of CO_2/year.
2. 1 hectare of tropical forest captures 4.3 tCO_2/year to 6.5 tCO2/year.
3. 1 tree absorbs approximately 1,000 kg of CO_2 *(Source: www.conservationfund.org/gozero).*
4. 1 hectare of trees stores 2,600 kg of carbon/year *(tree cover for urban areas is about 204 trees/acre, for forests it is about 480 trees/acre) (Source: coloradotrees.org).*

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Establish slope protection plan.
2. Identify locations of high and moderate risk erosion.
3. Protect existing slopes over 15% for undeveloped sites as required by local authorities.
4. Restore slope areas with native plants or non-invasive adapted plants.
5. No construction on sites under Class IV category *(Source: www.townplan.gov.my).*

4. PARAMETERS FOR LOW CARBON CITIES

URBAN ENVIRONMENT	
Performance Criteria **URBAN FORM**	
UE 2-1	**Mixed-Use Development**

Intent

Encourage mixed-use development by promoting transport efficiency and walkability.

Description

Mixed-use development is a building or complex that includes a mixture of land uses. Typically, the term is used when residential uses are combined with office, commercial, entertainment, childcare or civic uses such as schools, libraries or government services.
(Source: Useful Community Development)

A mixed-use development discourages single land use zoning and development and encourages higher density development. Integration between mixed use of sites and the building uses will help promote sustainability of the place. It will encourage people to walk to their daily activities. This reduces the need to travel by private vehicle or public transport as their daily needs can be easily accessed within the development.

Carbon Emission Reference

1. 1 km travel by car (petrol) emits 0.26 kg of CO_2.

Recommendations for Carbon Emission Reduction

Local authorities and other related agencies should take the following actions:-

1. Encourage intensity of land uses via mixed-use zone in development plans.
   - Increase housing options for diverse household types.
   - Encourage mixed-income communities.
2. Integrate isolated land use.

URBAN ENVIRONMENT	
Performance Criteria **URBAN FORM**	
UE 2-2	**Compact Development**

Intent

Encourage high-density developments with mixed activities by promoting transport efficiency and walkability.

Description

Compact development related to high residential density with mixed land uses as well as development intensity. Development intensity refers to density control for residential development and plot ratio control for developments such as commercial, mixed-use and industrial developments.

Encouraging higher intensity development within centres will promote mixed-use development and an efficient public transport system. The site layout or development, which considers compact development concept, will provide more space for green areas. Compact developments have a shorter distance between parts of the city. This reduces the need to travel, which directly reduces the emission of CO_2.

Carbon Emission Reference

1. 1 km travel by car (petrol) emits 0.26 kg of CO_2.
2. For earthwork activities (Source: Guidelines to Defra, 2009):
   - 1 km trip generates 0.85 kg of CO_2 via air pollution; and
   - 1 km trip generates 10.03 kg of CO_2 via diesel use.

Recommendations for Carbon Emission Reduction

Local authorities and other related agencies should take the following actions:-

1. Plot ratio control by limiting the floor area requirements for development types such as:-
   - Commercial;
   - Industrial; and
   - Mixed-use.

URBAN ENVIRONMENT	
Performance Criteria **URBAN FORM**	
UE 2-3	**Road and Parking**

Intent
Reduce environment effects through road and parking surfaces.

Description
Roadways and parking are the main requirements in a city; as facilities for the people and also for ease of movement. A road network connects people from one place to another while parking enables people to leave their vehicles. However, both of these elements contribute to emissions through the heat generated from the surfaces.

It is recommended that less than 20% of the total development area be provided with road and parking surfaces. Clearance of site for the purpose of development will release CO_2 into the atmosphere. In addition to that, CO_2 will be released from the embodied energy of materials used for road and parking surfaces.

Carbon Emission Reference
1. 1 hectare with 0.1 m thickness of asphalt emits 70,150 kg of CO_2/year.
2. 1 hectare with 0.1 m thickness of concrete pavement emits 15,800 kg of CO_2/year.

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Review road design and parking requirements (e.g.: not more than 20% of the total development footprint area with no individual surface parking lot larger than 2 acres).
2. Reduce the demand for new roads and parking lots.
3. For new non-residential buildings and multi-unit residential buildings, either:-
   - Do not build new off-street parking lots; or
   - Locate all new off-street surface parking lots at the side or rear of buildings, leaving building frontages facing streets free of surface parking lots.

URBAN ENVIRONMENT	
Performance Criteria **URBAN FORM**	
UE 2-4	**Comprehensive Pedestrian Network**

Intent

Reduce car dependency by establishing a comprehensive pedestrian network within the development area.

Description

Walking is well known as a non-motorised mode of transport. It emits zero CO_2 emission, thus gives no harm to the environment. In urban areas, the most efficient alternative for short distance movement or trip is via walking and cycling.

It is important to integrate pedestrian walkways with other activity nodes and public transport. Activity nodes such as schools, colleges and universities, offices, commercial areas and parks should be planned within walking distance (i.e. 400 m radius), designed with the aim of facilitating walking.

Carbon Emission Reference

1. Walking and cycling emit zero CO_2 emission *(Source: www.smartertavelsutton.org).*
2. CO_2 released into the atmosphere for clearing of sites to prepare for the pedestrian network.
3. CO_2 released from embodied energy of materials used for the construction of the pedestrian network.

Recommendations for Carbon Emission Reduction

Local authorities and other related agencies should take the following actions:-

1. Identify and demarcate areas where no private vehicular access is allowed.
2. Provide dedicated and continuous pedestrian walkways in current and future developments.
3. Provide sufficient pathways for pedestrians with covered/shaded walkways.
4. Ensure safe and comfortable pedestrian walkways in all developments.
5. Incorporate the universal urban design along public sidewalks and internal pedestrian walkways, particularly those that lead to and from transit stops or stations.

URBAN ENVIRONMENT

Performance Criteria
URBAN FORM

UE 2-5	Comprehensive Cycling Network

Intent
Reduce car dependency by establishing a comprehensive cycling network within development area.

Description
Apart from using public transport modes such as bus and train, there is a necessity to develop cycling as another choice in supporting sustainable transport. It is well known that one of the main factors that contribute to climate change and greenhouse gas emissions is dependency on private vehicles. Thus, cycling can help tackle this issue.

There is a need to make a change in people's behaviour by encouraging cycling to get to places a short distance away. Instead of using cars or motorcycles, people should use bicycles which emit zero CO_2. A comprehensive cycling network should be established within a development or city. The routes should be easily accessible and well connected.

Carbon Emission Reference
1. Walking and cycling emit zero CO_2 *(Source: www.smartertavelsutton.org).*
2. CO_2 released into the atmosphere for clearing of sites to prepare for the cycling network.
3. CO_2 released from embodied energy of materials used for the construction of cycling network.

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Identify and demarcate areas where no private vehicular access is allowed.
2. Provide dedicated and continuous lane for cycling in current and future developments.
3. Provide sufficient pathways for cycling with covered/shaded walkways.
4. Design and/or locate the cycling network to meet at least one of the three requirements below:-
   - An existing cycling network of at least 5 continuous miles in length within a 300 m cycling distance of the project boundary.
   - If the project is 100% residential, an existing cycling network begins within 300 m cycling distance of the project boundary and connects to a school or employment centre within a 3-km cycling distance; and
   - An existing cycling network within a 1/4-mile cycling distance of the project boundary connects to several diverse uses within 3 miles of cycling distance from the project boundary.
5. Provide bicycle repair services within the network and bicycle parking and storage capacity to encourage cycling.

URBAN ENVIRONMENT

Performance Criteria
URBAN FORM

UE 2-6	Urban Heat Island (UHI) Effect

Intent
Reduce urban heat island effect in the cities or townships.

Description
UHI refers to a phenomenon where the cities and townships are significantly warmer than their surrounding areas. The temperature is slightly different between cities and their surroundings, due to major causes which are the lack of vegetation and the presence of dark surfaces (building materials). As urban heat islands lead to increased temperatures within cities and townships, they worsen the air quality.

The effects from the UHI can be seen through energy use, environmental pollution and general health of the city dwellers. Cities that experience the UHI phenomenon tend to increase their energy consumption through use of air conditioning. When the temperature becomes warmer due to the heat absorbed by the building surfaces and materials, the occupants of a building will increase the use of air conditioners.

The UHI can be reduced by providing more shade trees at streets and vegetation on roof tops as well as external façades of buildings. As a general rule, 10% increase in vegetation cover reduces the temperature by about three degrees, hence providing a cooling effect to the surrounding environment.

Carbon Emission Reference
1. A tropical forest absorbs 5.5 kg of CO_2/year.
2. 2. 1 hectare of tropical forest captures 4.3 tCO2/year to 6.5 6.5 tCO_2/year.
3. 1 tree absorbs approximately 1,000 kg of CO_2 *(Source: www.conservationfund.org/gozero).*
4. 1 acre of trees stores 2,600 kg of carbon/year (where tree cover for urban area is about 204 trees/acre, for forest it is about 480 trees/acre) *(Source: coloradotrees.org).*

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Incorporate urban form guidelines to achieve natural climate conditions in development plans.
2. Encourage mixture of high-rise and low-rise buildings and innovative building orientation for sunlight and wind.
3. Encourage innovative building designs incorporating features such as roof gardens and vertical gardens.
4. Increase percentage of tree coverage from the total land areas.
5. Provide more parks and gardens in development plans.
6. Plant more trees near office blocks, along streets and within residential areas.
7. Use grid block at parking area to reduce the heat island effect and surface runoff.
8. Use water-retentive pavement or other pavement materials that help to reduce heat.
9. Use grid block at parking areas to reduce the heat island effect and surface runoff.
10. Use solar reflective coatings or light colour for building surfaces to reflect heat.
11. Use paving materials of solar reflective index (SRI) 29 or higher; and
12. Provide open grid areas (parking, roads and sidewalks) with paving material of SRI 29.

URBAN ENVIRONMENT	
Performance Criteria **URBAN GREENERY AND ENVIRONMENT QUALITY**	
UE 3-1	**Preserve Natural Ecology, Water Body and Biodiversity**

Intent

To provide natural restoration of carbon by improving urban biodiversity through preservation and conservation of natural environment and water bodies or wetlands.

Description

Biodiversity is defined as the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; including diversity within species, between species and of ecosystems. *(Source: National Physical Plan-2)*

Meanwhile, natural ecology also includes wetlands which provide many benefits to society. They are among the most productive and biodiverse ecosystems in the world - comparable to rain forests and coral reefs. They help improve water quality, including that of drinking water, by intercepting surface runoff and removing or retaining inorganic nutrients, processing organic wastes and reducing suspended sediments before they reach open water.

Natural ecology and water body provide natural restoration of CO_2. Hence, disturbing the ecology and water bodies for development purposes will release CO_2 into the atmosphere. Meanwhile, a large body of water such as a lake or wetland can absorb CO_2 already present in the air and function as a carbon sink.

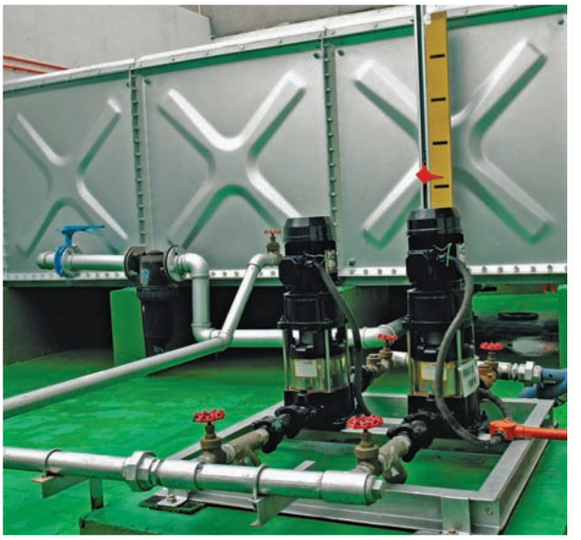
Carbon Emission Reference

1. A tropical forest absorbs 5.5 kg of CO_2/year.
2. 1 hectare of tropical forest absorbs 4.3 tCO_2/year to 6.5 tCO_2/year.
3. 1 hectare of tropical wetlands absorbs 1.48 tCO2/year.
4. 1 tree absorbs approximately 1,000 kg of CO_2 *(Source: www.conservationfund.org/gozero).*
5. 1 acre of trees stores 2,600 kg of carbon/year (where tree cover for urban area is about 204 trees/acre, for forest it is about 480 trees/acre) *(Source: coloradotrees.org).*

Recommendations for Carbon Emission Reduction

Local authorities and other related agencies should take the following actions:-

1. Incorporate green and blue corridors in development plans.
2. Identify possible sites for environmental sensitive protection.
3. Preserve forests, wetlands and water bodies.
4. Enhance urban biodiversity through the enhancement of existing habitats and creation of new habitats.



URBAN ENVIRONMENT

Performance Criteria
URBAN GREENERY AND ENVIRONMENT QUALITY

UE 3-2	Green Open Space

Intent
Increase percentage of green open space within cities or townships.

Description
Open space is specifically for public use or benefit. In general, it refers to land or space allocated as an area for relaxation/ picnic and recreation. It includes gardens, children's playground, playfield, sports ground, floral garden as well as landscaped and planned area. *(Source: National Urbanisation Policy)*

Green open space is important as it helps to reduce the GHG and beautify the landscape of a city and is simultaneously vital for the people. This shows that green open space is important not only to help reduce the GHG, but also as a recreational area for the city dwellers to relax and play. Plants can absorb CO_2 during photosynthesis which leads to carbon sequestration.

Carbon Emission Reference
1. A tropical forest absorbs 5.5 kg of CO_2/year.
2. A hectare of tropical forest absorbs 4.3 tCO_2/year to 6.5 tCO_2/year.
3. 1 tree absorbs approximately 1,000 kg of CO_2 *(Source: www.conservationfund.org/gozero).*
4. 1 acre of trees stores 2,600 kg of carbon/year (where tree cover for urban area is about 204 trees/acre, for forest it is about 480 trees/acre) *(Source: coloradotrees.org).*

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Gazette green open space.
2. Preserve more forest and green spaces.
3. Increase percentage of tree coverage from the total land area.
4. Incorporate requirements for specific green areas near office blocks, along streets and within residential areas through tree planting.
5. Plant fast growing, decorative and low-maintenance types of vegetation.

URBAN ENVIRONMENT	
Performance Criteria **URBAN GREENERY AND ENVIRONMENT QUALITY**	
UE 3-3	**Number of Trees**

Intent
Increase percentage of tree coverage within cities or townships.

Description
Trees are the most beneficial element that helps the environment. As trees mature, they will save greater amounts of carbon. For instance, a ten-year-old tree will sequester more carbon than a five-year-old tree, but not as much carbon as a twenty-year-old tree. In short, increase in the number of trees results in increase in carbon sequestration *(Source: www.upsonemc-carbonoffset.com/C02treestore).*

With this, the CO_2 emission in a city can be reduced through a natural process. Trees can absorb CO_2 during photosynthesis, which helps in cooling the environment, removing air pollutants, lowering GHG emissions and simultaneously reducing the urban heat island effect. In simple words, trees are the most useful and effective tool if they are planted in strategic locations within the city.

Meanwhile, the increase in percentage of tree and vegetation coverage also indirectly improves the air quality.

Carbon Emission Reference
1. The upper (green) vegetation of a tropical forest absorbs 5.5 kg of CO_2/year.
2. A tree absorbs approximately 1,000 kg of CO_2 *(Source: www.conservationfund.org/gozero).*
3. 1 acre of trees stores 2,600 kg of carbon/year (where tree cover for urban area is about 204 trees/acre, for forest it is about 480 trees/acre) *(Source: coloradotrees.org).*

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Incorporate a tree planting programme and campaign.
2. Increase percentage of tree coverage of the total land area.
3. Increase the number of trees near office blocks, along streets and within residential areas.
4. Encourage planting of fast growing, decorative and low-maintenance types of vegetation.
5. Organise a landscaping competition among schools to promote the "go green" culture among the younger generation (students).

URBAN TRANSPORT

Performance Criteria
SHIFT OF TRANSPORT MODE

UT 1-1	Single Occupancy Vehicle (SOV) Dependency

Intent
Reduce the overall number of single occupancy vehicle trips and proportionately increase the number of passengers in a vehicle to lower the average passenger per capita carbon footprint.

Description
SOV refers to a private operated vehicle where the only occupant is the driver. Such vehicles are used mostly for personal travel, daily commuting and running daily errands. The increasing trend in SOV dependency especially in urban areas contributes greatly to carbon emission into the atmosphere, thus leading to global environmental problems such as global warming *(Source: en.wikipedia.org/wiki/single-occupant vehicle).*

Based on this scenario, there is a need to lessen dependency on SOV in order to reduce the carbon generated into the atmosphere. This can be achieved by encouraging greater use of public transport. An alternative to the car should be provided, for instance ensuring the availability of an efficient public transport system in selected areas. This can achieve the targets of reducing private car dependency while at the same able contributing to CO_2 reduction.

This is why choices of public transport, its quality and the distance people are prepared to travel in different modes will determine their choice of transport mode, thus help to lessen SOV dependency and reduce CO_2 emission.

Carbon Emission Reference
1. Average 64.4 km/car/day = 17.6 kg of CO_2 emission
2. Average 64.4 km/bus/day = 1.6 kg of CO_2 emission
   (Source: ACTR- Public Transit vs. Single Occupant Vehicles Carbon Emissions to Climate Change)

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Determine the public transport policy in development plans.
2. Review car-parking requirements and increase car-parking charges in CBD or selected areas.
3. Ensure service provided is sufficient (i.e.: increase the bus rapid transit service frequency).
4. Implement TOD with transit station or as the centre of development based on transit support, connectivity, multimodal and place making.
5. Implement road area pricing and congestion charges in selective areas (i.e.: CBD).
6. Increase 'park & ride' areas.

4. PARAMETERS FOR LOW CARBON CITIES

URBAN TRANSPORT

Performance Criteria
GREEN TRANSPORT INFRASTRUCTURE

UT 2-1	Public Transport

Intent
Achieve a 10 to 40% reduction in the number of daily commuters from using private vehicles to public transport, and lower each passenger's per capita carbon footprint.

Description
Public transport is an efficient mode of travel where it can accommodate a large number of passengers at one time and offer a wide coverage of destinations. For instance, public transport is a primary mode of transport in cities like Singapore, Hong Kong, Australia and Curitiba. In Curitiba, for example, 40% of the population uses public transport as the commuting mode while in Hong Kong, more than 90% of the population uses public transport and that excludes walking. This shows that public transport can be the preferred choice if the system works efficiently *(Source: Public Transport: Lessons To Be Learnt From Curitiba and Bogota).*

Furthermore, this commuting mode can contribute to reducing each passenger's per capita carbon footprint. Encouraging or shifting the daily mode of travel to a clean fuel powered mass public transport system instead of private vehicle travel is able to reduce CO_2 on each kilometre travelled. This approach of shifting from private vehicle to low emission public transport as a means of daily travel should be adopted as a continuing effort, which leads to reduction in CO_2 emission.

On the other hand, to ensure the efficiency of public transport service, it should be provided within a reasonable walking distance of one's origin and destination. The key aspect that determines one's choice of transport is the existence or absence of transit services within or near to one's origin and destination. Higher capacity transit systems, use of bus lanes and the Integrated Transport Information System (ITIS) are a few initiatives that could also be implemented to improve the system, while at the same time reduce the carbon emission into the atmosphere.

Carbon Emission Reference
1. Average 64.4 km/car/day = 17.6 kg of CO_2 emission
2. Average 64.4 km/bus/day = 1.6 kg of CO_2 emission
   (Source: ACTR- Public Transit vs. Single Occupant Vehicles Carbon Emissions to Climate Change)

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Identify and demarcate areas where no private vehicular access is allowed.
2. Increase coverage of areas within transit stations and rail corridors.
3. Provide well-planned covered and safe (especially at night) walkways or bicycle ways leading up to feeder transport.
4. Provide ample and secure car, motorcycle and bicycle parking in order to ensure ease of use of all public transport facilities.
5. Provide vehicles with low carbon emissions as feeder transport for passengers travelling to public transport stations or hubs.

URBAN TRANSPORT

Performance Criteria
GREEN TRANSPORT INFRASTRUCTURE

UT 2-2	Walking and Cycling

Intent
Achieve a 10 to 40% reduction in the type of fossil fuel utilised for the purpose of powering public transport modes and this fuel is gradually replaced with clean fuels produced from renewable sources.

Description
Walking and cycling are also known as non-motorised modes of transport. In urban areas, for instance, the most efficient alternative for short distance movement or trip is via walking and cycling. In addition, in several countries like Australia, Canada and Hong Kong, these modes are increasingly popular not only because they are safe and convenient, but also give a lot of benefits. Looking back at the ultimate goal of transport, the idea is to provide access for the people to shop, work, relax and more. If the transport choices are wider, they will give better access to the people.

With emissions from private or public transport being one of the top threats to the environment, there is a need to adopt a strategic approach to increase low to zero emission travel. To reduce CO_2 emissions and energy consumption from the transport system, typically we can engage with one of two initiatives, either changing technology or changing behaviour. This initiative can be achieved by integrating the pedestrian and cycling networks with the other activity nodes and public transport system.

Other than that, the streets should be designed with the aim of facilitating walking and cycling. In order to achieve lower CO_2 emission and promote walking and cycling, the number of parking spaces which attached to destination should be reduced. This will encourage people to walk and cycle to reach their destinations. Thus, the initiative of switching from conventional private vehicle, or low emission public transport to zero emission transport modes should be encouraged comprehensively in the local context, which can gradually increase the reduction of CO_2 emission into the atmosphere.

Carbon Emission Reference
1. Walking and cycling release 0 kg of CO_2 *(Source: www.smartertavelsutton.org).*
2. 1 km round trip walking and cycling saves 6 kg/day of CO_2 (carbon savings per day compared to the use of car) *(Source: www.smartertavelsutton.org).*

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Identify and demarcate areas where no private vehicular access is allowed.
2. Provide dedicated lanes for cycling and walking.
3. Provide sufficient pathways for pedestrian with covered/shaded walkways.
4. Create pedestrian and cycling "short cuts" that lead directly to transit. Pathways require a minimum 6-metre right-of-way. Look for opportunities to link "short cuts" to the larger green space, pedestrian and cycling networks.

URBAN TRANSPORT	
Performance Criteria **CLEAN VEHICLES**	
UT 3-1	**Low Carbon Public Transport**

Intent
Achieve a 10 to 40% reduction in the type of fossil fuel utilised for the purpose of powering public transport modes and this fuel is gradually replaced with clean fuels produced from renewable sources.

Description
Public transport is one of the alternatives in reducing CO_2 emissions in addition to walking and cycling. Public transport comprises the bus, train, tram, ferry and several more modes. Though use of public transport can help the environment and ease congestion, it may still be harmful. Take the example of the bus. The use of fuel to run a bus will affect the quality of air. More fuel burned means more natural resources are used and more pollution is created due to the extraction and processing of the fuel.

According to a source quoted from the Green Vehicle company, electricity is approximately 80% cleaner than gas engine. Besides using electricity as an alternative, another way to achieve clean engine motor vehicles is via biofuel or biodiesel. These sources emit less CO_2 compared to conventional petroleum-based gasoline and diesel fuels.

Clean fuel on-road and non-road public transport modes can significantly reduce CO_2 emission into the atmosphere for each kilometre travelled. Public transport modes powered by clean fuel offer the advantages of cleaner operation than conventionally powered transport modes. This is due to the absence of polluting by products produced by internal combustion engines *(Source: www.epa.gov/greenvehicles/Wcyd.do).*

Carbon Emission Reference
1. NGV emits 0.2 kg of CO_2/km *(Source: ACTR- Public Transit vs. Single Occupant Vehicle Carbon Emissions to Climate Change)*

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Formulate a green vehicle policy.
2. Provide riders with a simple carbon calculator to determine how much carbon is abated due to the use of an alternative clean fuel driven public transport system.
3. Organise more green awareness campaigns on clean fuel use.

URBAN TRANSPORT

Performance Criteria
CLEAN VEHICLES

UT 3-2	Low Carbon Private Transport

Intent
Achieve a 10 to 40% shifting of conventional private vehicle to low carbon vehicle to ensure less carbon is generated into the atmosphere, thus creating a healthier environment that is essential to our well-being.

Description
A conventional vehicle is one of the major contributors of CO_2 emission through fuel combustion during vehicle operation. For instance, the average conventional vehicle emits 6000 to 9000 kg of CO_2 which leads to global warming potential. One of the effective ways to reduce CO_2 emission from the conventional vehicle is to switch to a lower carbon type of vehicle, for instance, a hybrid vehicle.

An example of a low carbon vehicle emitting less CO_2 is a hybrid vehicle merging the features of a conventional engine and electric vehicle. The combination allows the electric motor and batteries to operate the combustion engine more efficiently, thus cutting down on fuel use. As a result, this type of vehicle will produce less combustion, thus significantly reducing the CO_2 emission. Nonetheless, there are several barriers to using this type of vehicle such as the expensive battery technology, limited driving range and the need for a dense network of charging facilities. According to the European Environment Agency, such a battery costs EUR 15,000 to EUR 40,000, which is RM 65,000 to RM 173,000. In order to cater for the cost and encourage wider green vehicle use, some cities and countries provide the users incentives like tax rebates, subsidies, free parking in urban areas and exemption from congestion charges and road taxes *(Source: www.eea.europa.eu/articles/the-electric-car-2014-a-green-transport revolution-in-the-making)*.

Even though the low carbon vehicle such as the hybrid car in the current market is normally more expensive than the conventional vehicle, it pays off in the long term for the environment and also the user. Furthermore, more users switching from conventional vehicles to low carbon vehicles will contribute to money savings and significantly help reduce CO_2 emission, hence helping to prevent global warming. Another benefit of using low carbon vehicles is the vehicles consume less fuel, resulting in the use of fewer natural resources *(Source: ktn.innovateuk.org/)*.

Carbon Emission Reference
1. A car using petrol generates 0.162 kg of CO_2/km.
2. A car using diesel generates 0.169 kg of CO_2/km.
3. A car using NGV generates 0.130 kg of CO_2/km.
4. An electric car generates 0.135 kg of CO_2/km.
   (Source: www.globalpetroleumclub.com)

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Convert existing government vehicles from conventional low carbon vehicles (hybrid cars).
2. Encourage combination of diesel and electric motor or biodiesel engine.
3. Impose condition for charging point facilities for hybrid vehicles on all applications for petrol stations.
4. Provide facilities such as public charging infrastructure in parking and neighbourhood areas.
5. Provide locational incentives, e.g. parking charge reduction.
6. Implement and monitor public awareness campaigns.

URBAN TRANSPORT	
Performance Criteria **TRAFFIC MANAGEMENT**	
UT 4-1	**Vehicle Speed Management**

Intent

Achieve optimum average vehicle speed that will result in economical consumption of fuel irrespective of whether the fuel consumed is conventional fossil fuel or clean fuel.

Description

The average speed of motor vehicles differs according to the types of road in different circumstances. Different mix of traffic mode requires different approaches in achieving effective speed management, for example the differences between urban and rural settings. Speed limit contributes to lowering emissions. For instance, CO_2 emission in heavily congested urban areas can be reduced to a lower level with a proper speed limit.

Many tools can be used to achieve effective speed management and also to reduce the amount of CO_2 generated into the atmosphere, which involve speed limits and engineering treatments. This is to ensure that the users comply with the speed signs and the laws. This will also increase the safety standard of the roads.

Thus, appropriate speed limit management helps reduce fuel consumption, which leads to reduction of CO_2 emission into the atmosphere.

Carbon Emission Reference

1. A speed of 113km/h could use up to 30% more fuel than 80 km/h.
2. Reduction in CO_2 of about 20% can be obtained by techniques to mitigate congestion in urban areas *(Source: Matthew Barth and Kanok Boriboonsomsin).*

Recommendations for Carbon Emission Reduction

Local authorities and other related agencies should take the following actions:-

1. Provide a comprehensive and integrated traffic management plan.
2. Improve traffic engineering (e.g. road design and services) for efficient speeds.
3. Improve level of compliance with speed limits through strict traffic law enforcement.
4. Increase active systems such as traffic lights, smart traffic control and ITIS (Integrated Transport Information System) to overcome congestion issues.
5. Increase passive systems such as strategically placed speed bumps as well as pedestrian crossings.

URBAN TRANSPORT

Performance Criteria
TRAFFIC MANAGEMENT

UT 4-2	Traffic Congestion and Traffic Flow Management

Intent
Ensure smooth flow of traffic throughout the development.

Description
Traffic congestion is a growing problem globally. Congestion happens due to increasing car ownership, easy access to a wide range of activities in the city and also lack of and inconvenient paths for walking and cycling. People prefer to use cars to get to their destination even a short distance away. Building more roads is no longer a solution to this problem and cannot be implemented any more as it leads to the increasing number of vehicles while at the same time generating more CO_2 into the atmosphere.

The more time vehicles spend on the road, the higher the fuel consumption and CO_2 emissions. For instance, more CO_2 will be generated by vehicles when the engines are idling during traffic congestion.

Stockholm, for example, managed to cut traffic gridlock by 20%, reduce emissions by 12% and increase public transport use dramatically through the Smart Traffic System. This shows that with appropriate traffic flow management, traffic congestion can be prevented and the amount of CO_2 generated into the atmosphere will be lessened *(Source: Texas Transportation Institute; TTI's-Urban Mobility Report).*

Carbon Emission Reference
1. Traffic management strategies could reduce CO_2 emissions by 7-12%.
2. Average vehicle speed of >72 to <105 km/h or (for a freeway scenario) will reduce CO_2 emissions *(Source: Matthew Barth and Kanok Boriboonsomsin).*

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Address the Traffic Impact Assessment (TIA) within the city. The 'worst case scenario' should be deliberated upon in great detail.
2. Lay out new streets, lanes, pedestrian and cycling connections in a connected network of short block lengths that offer route choice.
3. Use appropriate and clearly defined innovative traffic calming techniques that promote a smooth flow of traffic.
4. Prioritise ingress and egress of a development when connecting to the outside of the township to ensure sufficient and smooth flow in or out of the development.
5. Increase active systems (i.e. traffic lights, smart traffic control and ITIS) and passive systems (i.e. strategically placed speed bumps as well as pedestrian crossings).
6. Harness the technology and other mitigation strategies in traffic management such as congestion pricing, incident management.

URBAN INFRASTRUCTURE

Performance Criteria
INFRASTRUCTURE PROVISION

UI 1-1	Land Take for Infrastructure and Utility Services

Intent
Reduce land take by adequately designed main infrastructure trenches that will cater for all under and above ground services for current and future needs.

Description
Land take happens due to the dispersion of development. It can be for housing, transport, infrastructure, services, recreation and more. Land take is commonly to cater for infrastructure purposes and normally involves greenfield areas and open spaces.

The provision of infrastructure facilities in any given development takes up 50% of developable land. This land take will accommodate road networks, reserves for water tanks, sub-stations, sewerage treatment plants and reserves for the reticulation networks of water, electricity and telephone cables, high speed broadband cables, etc.

This high percentage in land take means land use inefficiency and more space requirement, leading to more land use changes. Changes in land use, for example from greenfield area to infrastructure use, can generate high carbon emissions. Hence, efficiency in land use, especially for the provision of urban infrastructure facilities, can help reduce carbon emission.

Carbon Emission Reference
1. 1 acre of developed infill or brownfield area = 7,000 kg of CO_2 emission (every acre of infill and brownfield development used for infrastructure reserve can reduce 30% of CO_2 emission compared to Greenfield area) *(Source: Congressional Research, 2009).*

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Review the design by considering green initiatives undertaken by the developer or local authority.
2. Allow greater use of land due to greater planning efficiency.
3. Identify a 'spine' of the township to integrate existing infrastructure.
4. Encourage sharing and optimizing utility reserves.
5. Incorporate a 'spine' utility reserve system into the township.
6. Optimize design to cater to new technology, i.e. needs, systems, materials and methodologies.
7. Identify depth and gradient during design development stages.
8. Reduce the carbon footprint of natural lighting and ventilation during operations and life span of the shared utility reserve.

URBAN INFRASTRUCTURE

Performance Criteria
INFRASTRUCTURE PROVISION

UI 1-2	Earthwork Management

Intent
Promote well planned earthwork and construction activities on site that will ensure minimal cut and/or fill work.

Description
Description
Earthwork is the first activity that takes place during construction. It involves cut and fill of a certain volume of earth and movement of trucks to import and export earth.

Earthwork construction involves the use of trucks that consume energy for their movements within the site as well as externally. This has a detrimental impact on the environment arising from energy consumption and gas emissions. Moreover, it generates noise pollution as well as soil sedimentation.

Choosing the most suitable sites for construction will be the basis to reduce carbon emission in earthwork management. Reduced earthwork would mean less carbon. Furthermore, earthwork should limit grading as it can reduce costs for construction machinery and transport of imported soils. Moreover, proper earthwork and efficient design will also help to conserve the existing natural areas, restore damaged areas and protect biodiversity.

Carbon Emission Reference
1. 1 km trip of dump truck = 0.85 kg of CO_2 via air pollution
2. 1 km trip of dump truck = 10.03 kg of CO_2 via diesel use
   (Source: Guidelines to Defra, 2009)

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Adopt earthwork sustainable design and optimization approaches by limiting earthwork movements, i.e. cut and fills.
2. Encourage use of biodiesel to reduce fossil fuel based carbon emissions.
3. Prioritise transporting soil from cut and fill within the project area as a first preference.
4. Reduce cut and fill work to the bare minimum.

URBAN INFRASTRUCTURE	
Performance Criteria **INFRASTRUCTURE PROVISION**	
UI 1-3	**Urban Storm Water Management and Flood Mitigation**

Intent
Manage urban storm water runoff and reduce flooding impact to enhance water quality and natural hydrological systems as well as to protect life and property.

Description
Storm water comes from rainwater that is collected and carried away into the drainage system. Unsystematic drainage can cause blockage, which will then lead to overflowing water onto dry land or road surfaces. Even worse, overflowing water plus heavy rainfall can lead to flash floods.

Floods cause damage to people, property and the environment too. Malaysia is a tropical country that receives high rainfall throughout the year. Due to the heavy downpours, most states in the northern and eastern parts of Peninsular Malaysia like Kedah, Perlis, Kelantan and Terengganu face severe flooding every year.

It is important to have good storm water management techniques to control instances of flooding. One of the techniques is preservation of vegetation and water bodies. Vegetation, for example, not only helps to capture rainwater, but also restore CO_2. Pervious pavement for road surfaces and turf block for parking areas are other effective techniques. They reduce the storm water runoff flow rate and volume, simultaneously preventing flooding from occurring.

Carbon Emission Reference
1. Carbon sequestration by trees, plants and water bodies.

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Establish a local floodplain management plan.
2. Storm water management plan
3. Establish an integrated coastal /shoreline management plan.
4. Identify locations of high and moderate risk floodplain.
5. Develop only sites outside of the floodplain or sites that have been previously developed, in particular areas that have a 100-year high or moderate risk of flooding.
6. Establish flood mitigation strategies in flood prone areas.
7. Revamp the drainage and irrigation system.

URBAN INFRASTRUCTURE

Performance Criteria
WASTE

UI 2-1	Construction and Industrial Waste Management

Intent
Reduce construction and industrial waste to the landfill by implementing an efficient and practical waste separation system on site.

Description
Construction and industrial waste consists of materials that are no longer needed at construction and industrial sites. It can be steel, wood, nails, bricks, concrete and others.

In general, construction and demolition (C&D) waste is bulky, heavy and mostly unsuitable for disposal by incineration or composting. This poses waste management problems in the urban areas of Asia. In recent studies conducted on the breakdown of waste in the central and southern regions of Malaysia, construction waste materials contributed to 28.34% of the total waste generated *(Source: Holm, 2001, cited in Kulatungaet al., 2006).*

Though the construction industry is one of the major sectors that contribute to the nation's GDP, it also has a detrimental impact on the environment through GHG emissions. For example, GHG in the steel sector is primarily the result of burning fossil fuels during the production of iron and steel *(Source: Berkeley National Laboratory-http://ies.lbl.gov/iespubs).*

There are many ways to reduce GHG emissions from the construction industry. Rather than dumping the construction waste in a landfill, it is much better if the waste is recycled. Other than that, the construction industry should minimise emissions from the design stage and use sustainable, local and recyclable materials. This will help to reduce embodied carbon and simultaneously reduce emissions.

Carbon Emission Reference
1. 1 kg of tile production emits 0.46 kg of embodied CO_2 *(Source: Guidelines to Defra, 2009).*
2. 1 kg of HDPE pipe production emits 2.0 kg of embodied CO_2 *(Source: Guidelines to Defra, 2009).*
3. 1 kg of plasterboard production emits 0.38 kg of embodied CO_2 *(Source: Guidelines to Defra, 2009).*
4. 1 kg of plywood production emits 0.81 kg of embodied CO_2 *(Source: www.extranetevolution.com).*

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Minimize wastage in the construction sector and industry activities.
2. Segregate construction and industry waste materials at source prior to recycling centre.
3. Increase the use of recycled construction materials from certified renewable sources, i.e. wood salvaged from demolition.
4. Identify the reuse of each category of waste within the site. Establish 'chain of custody' documentation and inform related team members of the site so their actions are aligned to the intent of maximizing all site waste.
5. Sell waste that absolutely cannot be used on site.
6. Encourage innovative solutions and replace the conventional system, i.e. formwork to IBS (Industrial Building System).
7. Promote awareness and establish guideline for construction and industry waste recycling centre by defining acceptance rules and policies, i.e. defining sizes and weights.

4. PARAMETERS FOR LOW CARBON CITIES

URBAN INFRASTRUCTURE

Performance Criteria
WASTE

UI 2-2	Household Solid Waste Management

Intent
Reduce household solid waste to the landfill by conducting measurable awareness campaigns to separate the waste at source.

Description
Household solid waste is generated from the house. It consists of daily items that people consume and discard such as food waste, plastics, bottles, tins, tissues and paper.

The most common method of waste disposal in Malaysia is the landfill. Over 180 landfill sites are located in Peninsular Malaysia alone with 50% being open dumping grounds. Valuable land area is taken up for dumping waste. The organic content in the waste (estimated at well over 60% in residential waste) threatens the ecosystem with adverse consequences for human well-being and health.

Solid waste, if not disposed of properly, can add to visual, air and water pollution, clogging of drains, waterways, breed air borne diseases and other nuisances. Moreover, it releases carbon that harms the environment.

Waste can otherwise be turned into something that is valuable and helps generate income. For example, dry waste increases in value when sold to recyclers while organic waste is easily convertible to biogas and compost which is good for the cultivation of organic vegetables for consumption.

Carbon Emission Reference
1. 7,300 kg of CO_2 emission/person/year or 2 kg of CO_2 emission/person/day - figure for Malaysia *(Source: United Nations, 2007)*
2. 1 km trip of dump truck = 0.85 kg of CO_2 via air pollution *(Source: Guidelines to Defra, 2009)*
3. 1 km trip of dump truck = 10.03 kg of CO_2 via diesel use *(Source: Guidelines to Defra, 2009)*

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Establish effective disposal practices.
2. Improve solid waste management through:-
   - Efficient system and appropriate technology adopted; and
   - Effective management of disposal site facilities.
3. Introduce innovative technologies and system at new facilities like transfer station, composting plant, sanitary landfill and thermal treatment plant.
4. Promote waste segregation at source.
5. Utilise biogas as a cooking fuel, power for vehicles or generation of electricity.
6. Use a well design method for organic waste.
7. Organise awareness campaign to sort and segregate kitchen waste from tin cans, broken glass and encourage 3R concept at community and national levels.

URBAN INFRASTRUCTURE

Performance Criteria
ENERGY

UI 3-1	Energy Optimisation

Intent
Optimise energy consumption through a design review, technology and innovation with a target of 10 to 40% reduction of electricity.

Description
Energy consumption is the amount of power that is needed to generate something. According to the World Bank, the amount of energy consumption in Malaysia was 2,693 kg per capita in 2008 *(Source: data.worldbank.org).*

One of the large consumers of energy is street lighting. In Malaysia, municipal authorities provide street lighting which mostly uses the conventional bulb, leading to high consumption of energy and emission of CO_2 and SO_2.

Moreover, electricity consumption for street lighting forms a large part of municipal expenses. All this can be reduced by using solar panels for all street lamps or, alternatively, by converting to LED bulbs.

Conversion to LED bulbs for all street lighting within a municipal authority will greatly contribute towards carbon emission reduction. LED bulbs offer up to 80% savings on power consumption and ensure a complete return on investment in less than 17 months with colossal savings over the 10-year life of the product. They also reduce harmful CO_2 and SO_2 emissions.

Carbon Emission Reference
1. A normal street light bulb consumes 250-400W of energy and emits 0.17 kg of CO_2.
2. Every 1 kWh of energy used emits 0.68 kg of CO_2.
   (Source: www.gg-energy.com)

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Encourage the use of alternative energy and eco-friendly approaches such as sustainable designs, renewable energy, solar and wind energy.
2. Encourage day lighting and other innovations as an integral part of any design development.
3. Use low-energy consumption bulbs to light streets and other public spaces.

URBAN INFRASTRUCTURE	
Performance Criteria **ENERGY**	
UI 3-2	**Renewable Energy**

Intent
Utilise a mix in energy sources especially energy produced by solar, wind and biogas to ensure less carbon is generated into the atmosphere.

Description
Alternative sources of energy can be obtained from the sun, wind or water. As a country that has continuous sunshine, Malaysia can easily promote the use of renewable solar energy for its buildings, roads and other services. Using alternative sources of energy contributes to low carbon emission.

Alternatively, energy can also be sourced from gases. Methane gas, which is abundantly produced at waste landfill sites, can be trapped to provide energy for homes.

An example of use of this waste to energy supply is in the city of Kaohsiung, Taiwan. The largest landfill in the city provides methane gas to power homes. It is estimated that the power generated from methane gas lasts five years. Besides the waste to energy project, Kaohsiung also takes advantage of the sunlight. The city sets a target to install 20,000 photovoltaic by 2012 with the volume capacity 60 MW in producing 72 million kWh in electricity from solar power annually. That means a reduction of 46,000 tons of CO2 emissions *(Source: Mitigating Climate Change: What Taiwan Is Doing, Environmental Protection Administration, http: unfccc.epa.gov.tw).*

Carbon Emission Reference
1. Energy produced is 1170 to 1600 kWh/m2 for roof-top system.
2. Energy produced is 630 to 830 kWh/m2 for façade system.

Thus;
1. Every 1,000 kWh of energy used emits 0.68 kg of CO_2, thus:
   - 1 m^2 of solar panel saves 796 to 1088 kg of CO_2 /year for roof-top system.
   - 1 m^2 of solar panel saves 429 to 565 kg of CO_2 /year for façade system.
   (Source: www.gg-energy.com)

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Minimise energy consumed and give alternatives with lesser environmental impact.
2. Encourage collaborative efforts from the legislative and institutional bodies/organizations in promoting and implementing.
3. Consideration to install wind generators on tall buildings where the wind effect is more viable.
4. Good tax rebate and acceptance of new solar technologies (thin-film) to make solar energy a choice and not an option.
5. Promote awareness programme on benefits of alternative sources.

URBAN INFRASTRUCTURE

Performance Criteria
INFRASTRUCTURE PROVISION

UI 3-3	Site-Wide District Cooling System

Intent
Implement district cooling strategies that reduce energy use and adverse energy-related environmental effects.

Description
District cooling is a centralised cooling plant that is modern and environmental friendly. It is a system that distributes chilled water from a cooling plant to residential, commercial and industrial facilities. It is connected through a network of underground pipes.

District cooling gives several benefits in terms of energy savings and the environment. As much as 65% of electricity use can be reduced by district cooling compared to a traditional air conditioning system. Applying the district cooling system will also give a significant reduction of costs for operation and maintenance.

In terms of environmental benefits, district cooling is indirectly able to reduce a certain amount of CO_2, lessen air pollution, decrease emissions of ozone-depleting refrigerants, combat global warming and help control the demand for electricity *(Source: heating.danfoss.com).*

Carbon Emission Reference
1. The district cooling system indirectly helps to reduce as much as 40% of CO_2 emissions *(Source: District Heating&Cooling - A Vision towards 2020-2030-2050, DHC+Technology Platform, 2009).*

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Reduce energy use and adverse energy-related environmental effects by employing district cooling strategies.

URBAN INFRASTRUCTURE	
Performance Criteria **WATER MANAGEMENT**	
UI 4-1	**Efficient Water Management**

Intent

Optimised consumption of treated city supplied water through awareness of wastage and wasteful practices. Also, to achieve an alternative source of water through reuse of city water and rainwater harvesting for non-human contact purposes.

Description

Annually, there is an estimated 1.99 billion m^3 or 37% of non-revenue water (NRW). This is the amount of water that is lost in the system – the difference in the supply of water produced and the consumption of water within a region. It is estimated that carbon emission in the production of 1 million litres of water are 276 kg/ml *(Source: www. water.org.uk/home/policy/reports/sustainability-indicators-2007-08).*

The figure implies that there is an insurmountable amount of carbon lost in the NRW. There is thus a need to better manage water that is produced. Methods like reusing and recycling water can help to reduce carbon emissions where less water needs to be produced for urban services and daily uses like washing the car and watering the plants. Reusing and recycling water can be done through rainwater harvesting and grey water recycling. Heavy rainfall in this country should be benefited than left as surface water runoff.

Carbon Emission Reference

1. 1 million litres of water emits 276 kg of CO_2.
   (Source: www. water.org.uk/home/policy/reports/sustainability-indicators-2007-08)

Recommendations for Carbon Emission Reduction

Local authorities and other related agencies should take the following actions:-

1. Improve the water management system by reducing non-revenue water (NRW).
2. Establish renewable engineering to reduce physical losses due to leakages.
3. Encourage rainwater harvesting for outdoor use, i.e. irrigation.
4. Reduce surface runoff flow rate by introducing swells as an alternative to concrete culverts.
5. Reduce dependency on potable water for outdoor use.
6. Establish a sharp increase in water tariff beyond a certain usage limit.
7. Encourage the use of air-pressurised water to give the perception of high volume flow as an alternative.
8. Encourage the use of low flow sanitary fittings to ensure optimised use of water.
9. Give incentives for the implementation of water reuse for households and commercial properties.

BUILDINGS

Performance Criteria
LOW CARBON BUILDING

B 1-1	Operational Energy Emissions

Intent
To design and construct low carbon buildings with low operational energy emissions and monitor performance through measurement, reporting and verification (MRV).

Description
The Common Carbon Metric (CCM) is an initiative by the United Nations Environment Programme (UNEP-SBCI) to enable emissions from buildings to be consistently assessed, compared and the improvements measured.

The intention of the CCM is to give the building sector a guide to measure, report and verify reductions in a consistent and comparable way. The building sector contributes to carbon footprint through 40% of energy use, 30% of raw material use, 25% of solid waste, 25% of water use and another 12% of land use. Additionally, 80 to 90% of the energy used by the building sector is consumed during the operational stage of the life cycle of the building *(Source: www.unep.org/Common Carbon Metric, UNEP).*

The CCM for Malaysia established by the Ministry of Green Technology & Water and Malaysian Green Technology Corporation provides the baseline of building typologies and benchmark needed for operational energy emissions and carbon reductions for achieving the national climate goals *(Source: www.unep.org/Common Carbon Metric, KeTTHA, MGTC, Malaysia).*

Carbon Emission Reference
1. 80 to 90% of the energy used by a building is consumed during the operational stage of the life cycle of the building *(Source: www.unep.org/Common Carbon Metric, UNEP).*

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Compare building performance to the benchmark set by the CCM for building typologies:-
   - Offices;
   - Residential buildings (multi-residential, row houses, detached);
   - Hotels;
   - Hospitals;
   - Schools / institutional buildings; and
   - Commercial (retail) & industrial buildings.
2. Encourage all large-scale businesses (e.g. office and commercial buildings) to submit GHG Reduction Plans.

BUILDINGS

Performance Criteria
LOW CARBON BUILDING

B 1-2	Operational Water Emissions

Intent
Reduce effects on natural water resources and burdens on the community water supply and wastewater systems and simultaneously achieve building performance standard through the MRV approach.

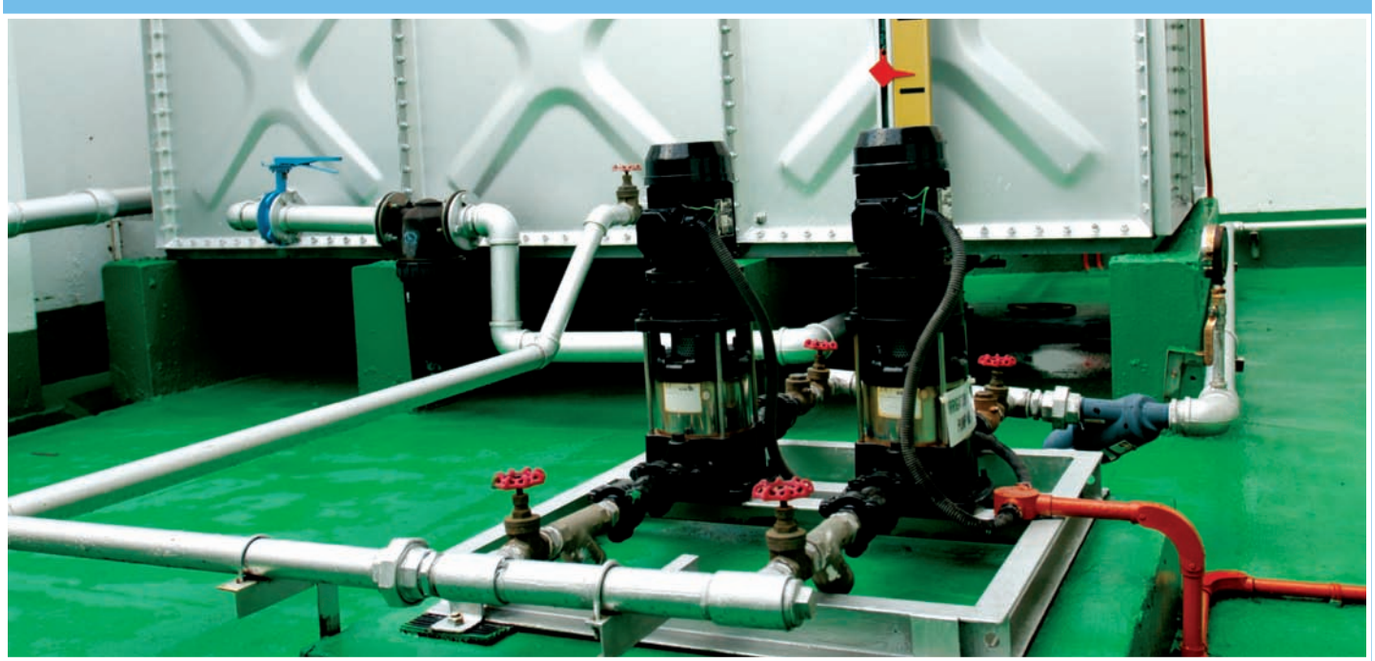
Description
Energy consumption in both new and existing buildings could be cut by an estimated 30-50% by 2020 through readily available technologies, design, equipment, management systems and alternative generation solutions (UNEP SBCI).

The Common Carbon Metric for Malaysia established by the Ministry of Green Technology & Water and Malaysian Green Technology Corporation provides the baseline of building typologies and benchmark needed for operational water emissions and carbon reductions for achieving the national climate goals *(Source: Common Carbon Metric, KeTTHA, MGTC, Malaysia).*

Low carbon buildings which comply with the building water operational emission benchmark will emit less GHG than regular buildings.

Carbon Emission Reference
1. The system processes for 1 cubic metre of water emits 0.419 kg of CO_2.
2. 1 million litres of water emits 276 kg of CO_2.
   (Source: www.water.org.uk/home/policy/reports/sustainability-indicators-2007-08)

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Compare building performance to the benchmark set by the CCM for building typologies:-
   - Offices;
   - Residential buildings (multi-residential, row houses, detached);
   - Hotels;
   - Hospitals;
   - Schools / institutional buildings; and
   - Commercial (retail) & industrial buildings
2. Encourage all large scale businesses (e.g. office and commercial buildings) to submit GHG Reduction Plans.
3. Indoor water use in buildings undergoing major renovations as part of the project must be an average 40% less than that in baseline buildings.



BUILDINGS

Performance Criteria
LOW CARBON BUILDING

B 1-3	Emission Abatement through Retrofitting

Intent
Reduce emissions from buildings through retrofitting in order to extend the life cycle of existing building stock and enhance the building performance.

Description
Carbon emissions generated from buildings cover all stages of their life cycle, namely, planning, design, construction, retrofitting and demolition.

Retrofitting extends the life cycle of a building by conserving resources and reducing adverse environmental effects in relation to resources, manufacturing and transport. These will also reduce the amount of demolition and construction waste deposited in landfills, and minimise use of natural resources for constructing a new building. Retrofitting also enables upgrading of buildings with systems using new technologies, therefore leading to CO_2 emission reduction.

The carbon emissions during retrofitting result from demolition and construction processes of new building forms.

Carbon Emission Reference
1. 1 ton of cement emits 0.93 ton of CO_2.
2. 1 ton of aluminium emits 8.24 tons of CO_2.
3. Energy produced is 1170 to 1600 kWh/m^2 for roof-top system.
4. Energy produced is 630 to 830 kWh/m^2 for facade system.

Thus;
1. Every 1,000 kWh of energy used emits 0.68 kg of CO_2, thus:
   - 1 m^2 of solar panel saves 796 to 1088 kg of CO_2 /year for roof-top system.
   - 1 $m^2$of solar panel saves 429 to 565 kg of CO_2 /year for façade system.
   (Source: www.gg-energy.com)

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Retrofit and reuse existing habitable building stock.
2. Do not demolish any historic buildings, or alter any cultural landscapes as part of the project.

BUILDINGS	
Performance Criteria **LOW CARBON BUILDING**	
B 1-4	**Building Orientation**

Intent
Optimise passive and active design strategies to reduce heat gain in buildings.

Description
Different buildings have different orientations. The orientation has a huge impact on heating, lighting and cooling costs.

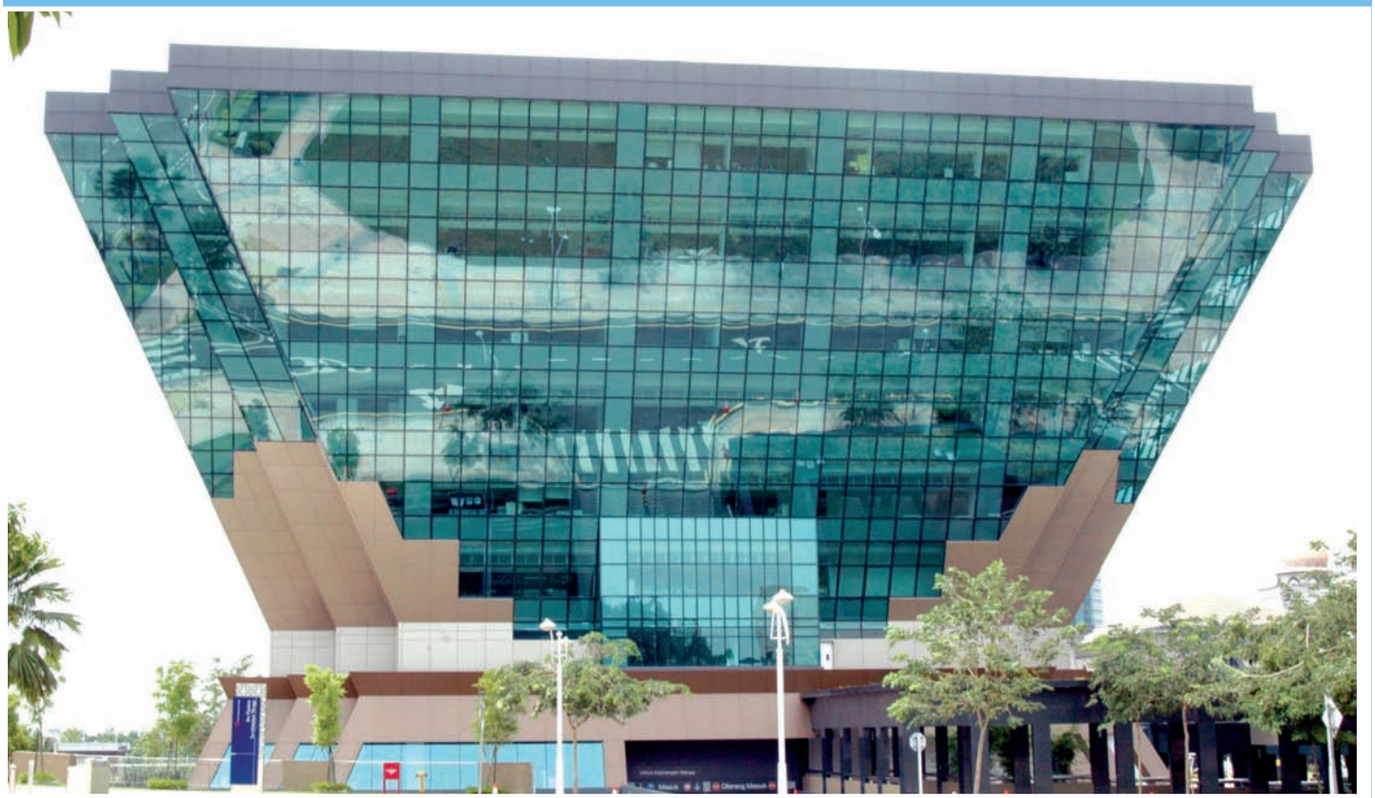
In hot humid climate, solar influence on energy consumption in buildings is significant; therefore design strategies are focused on reducing heat gain.

Building orientation affects air conditioning and heating energy requirements through:
a. Solar radiation, which has heating effects on walls and rooms.
b. Ventilation, which is associated with the direction of prevailing winds and building orientation.

Sustainable and passive solutions should be given priority during design. Innovative design can maximise building exposure to take advantage of the sun for daylight and solar heating.

Carbon Emission Reference
1. An 8-storey apartment building with east–west orientation experiences total solar gain of 0.14 kWh/m2 compared to 0.01 kWh/m^2 for a north-south orientation.
2. CO_2 emission can be reduced on-site from fossil fuel energy production and use.

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Prioritise passive solution on buildings.
2. Increase the harnessing of sunlight by looking to block orientation (compact development) and building orientation (natural ventilation, prevailing winds and wind zone).
3. Offset the mechanical HVAC systems for cooling purposes.



BUILDINGS

Performance Criteria
COMMUNITY SERVICES

B 2-1	Shared Facilities and Utilities within Building

Intent
Reduce land take for community services and encourage flexibility of use of buildings and simultaneously reduce carbon emissions due to sprawl and change of land uses.

Description
Land take is due to the dispersion of development where a large measure of agricultural land and forests has vanished. Land take can be for housing, transport, infrastructure, services, recreation and others. Development on greenfield sites to cater public facilities should be reduced as it allows sprawl and emits a lot of CO_2.

Facilities and community services such as kindergartens should be integrated with other building uses such as offices. A police station can be located in a commercial building and this can enhance the security within that area too. Sustainable land use planning not only helps reduce inappropriate land take especially for community services, it also helps to reduce CO_2 emission.

Carbon Emission Reference
1. 1. 1 acre of Greenfield area developed = 10,000 kg of CO_2 emission.
2. 1 acre of infill and brownfield area developed = 7,000 kg CO_2 emission (savings of 3,000 kg of CO_2 compared to Greenfield development) *(Source: Congressional Research Service, 2009).*

Recommendations for Carbon Emission Reduction
Local authorities and other related agencies should take the following actions:-
1. Share and integrate community service centres with other building use.
2. Save green sites and ensure sustainable land use.

5 THE LOW CARBON CITIES FRAMEWORK AND ASSESSMENT SYSTEM'S CALCULATOR, CONCEPT AND PRINCIPLES

5.1 About the LCCF Calculator

The GHG Calculator uses a library of emission factors and statistics, which converts inputs into greenhouse gas emissions. All of the calculations occur 'behind the scenes', meaning the tool appears simple, yet in the background, many complicated calculations are being performed. The intention is to produce a user-friendly calculator to encourage learning.

5.2 Who will use it?

As climate change becomes more evident, governments and stakeholders become more aware of the need to address these critical issues. The calculator has been designed for use by local authorities, planners and developers to design a low carbon city/township. The results produced by the calculator will show stakeholders the total greenhouse gas emissions produced by their cities/townships/development. It is critical that the industry develops an understanding of carbon emissions so that future efforts can be focused on improving reduction measures to arrive at the planned target.

5.3 The Relevance of the Assessment System and Calculator

The LCCF Calculator is relevant to both cities and townships for generating awareness of key environmental issues, provide technical assistance and training to build capacity in local governments to address these issues and evaluate progress of cities/ townships towards low carbon development.

Being a performance based system, the LCCF Calculator can be adopted by the government, local governments and authorities for a rigorous cycle of project management that progresses from an initial analysis of greenhouse gas emissions, through strategy development and implementation of mitigation measures, to monitoring, reporting and re-evaluating performance of cities / townships.

The usefulness of the LCCF Calculator can be summarized in four ways:-

- The performance based system measures actual results of the cities' impacts upon the environment, rather than potential impacts;
- It enables organizations with little experience to engage in the GHG accounting process, creating a common platform for measuring and reporting;
- It encourages states/local governments/local authorities to think and act with greater concern for the environment in targeting their national climate goals; and
- It stimulates early action from stakeholders towards climate change mitigation.

5.4 The Concepts and Principles

Carbon Sequestration

In this calculator, carbon sequestration refers to the absorption of carbon by trees, greenery and soils. The eco-region and the maintenance of landscaping both have an impact on the quantity of carbon that can be sequestered. Certain landscapes, like wetlands, have the capacity to store significant amounts of carbon. This carbon is released when the landscape is disturbed or destroyed.

Landscape should be considered in conjunction with site design and building as it is a key element of carbon sequestration. An estimate of the amount of ecosystem services in a development would provide us with a better sense of how we need to build our environment in order to live within the ecological limits. This calculator allows landscape impacts to be quantified and applied to the development carbon footprint in the following ways:-

Site development and net site carbon storage

i. Accounting for carbon emissions as a result of development of the site requires comparing the native carbon storage of the site to the storage after the site is developed. Site development typically results in a net positive carbon flow from the earth to the atmosphere. Using the same method developed by the IPCC to account for this depletion in carbon storage, it is possible to calculate the emissions associated with land development for buildings and urbanization (IPCC 2006);
ii. Carbon makes up roughly half the dry mass of vegetation. Ecologists have already gathered data to estimate the total weight of vegetation per hectare for different ecosystems. They have shown that the mass of vegetation ebbs and flows with each season in some ecosystems, with the greatest mass towards the end of the growing season;
iii. There is a concurrent cycle of dying and sprouting of trees and other plants. Over the course of several generations of trees and other vegetation, it is possible to know how much carbon is typically stored per acre of the ecosystem;
iv. At a time when there were no developments, the native vegetation on those sites stored a certain amount of carbon. By simply removing that vegetation to make room for buildings and infrastructure means that we are decreasing the ability of the earth to sequester and store carbon; and
v. Studies on carbon storage specific to land types have already been gathered by the IPCC for a variety of forests and grassland. The calculator uses local data from various sources and will be updated as more studies will be conducted. Most of the current data accounts for only above ground biomass whereas up to 80% of total biomass is located below ground.

Carbon Emissions

Embodied Construction Emissions

The embodied carbon emissions as a result of construction, retrofit and demolition have to be considered. Using life cycle assessment (LCA), it is possible to trace back all the energy used and the resulting carbon emissions from raw material extraction, processing, assembly or demolition, and transport during the development and construction processes. Besides the construction of buildings, embodied energy in a development includes from infrastructures

such as roads, parking and pavements.

Operation Emissions

The operation emissions in a development arise from:-

i. Energy consumption in buildings for the provision of thermal comfort, indoor air quality, lighting and electricity for plug loads. This area typically represents the greatest portion of carbon flow as a result of a building throughout its lifetime. The carbon emissions associated with building operations are approximately 80% of the total energy consumption (UNEP 2010);
ii. Energy consumption for the provision of fresh water to the population; and
iii. Energy consumption for the handling of waste (including wastewater).

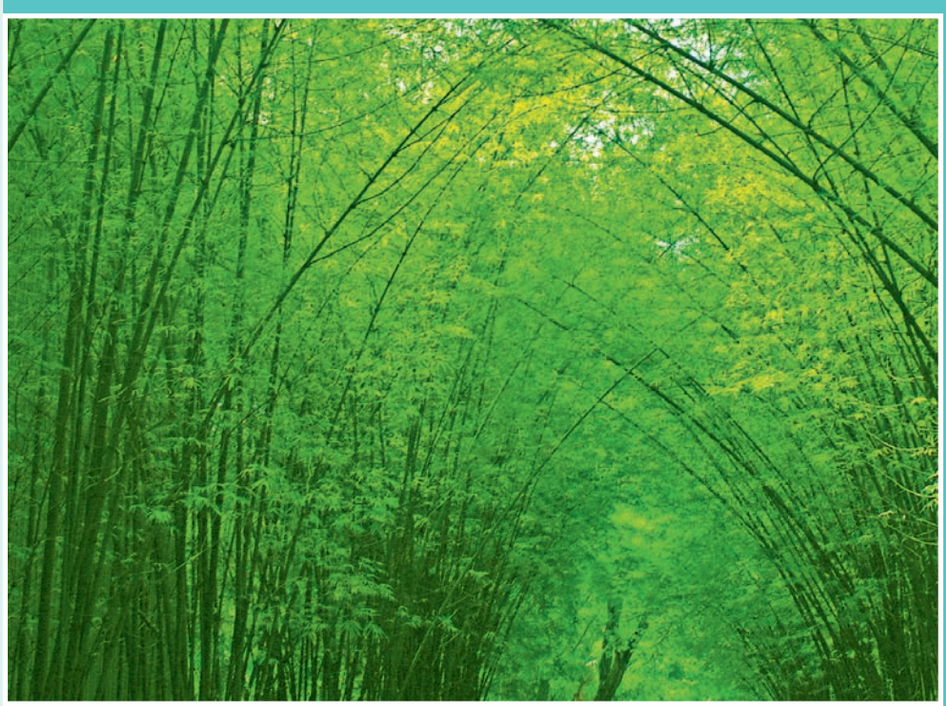
The LCCF Calculator emission coefficients for the conversion of energy into carbon dioxide used in the calculator are from local sources. It is important to acknowledge the fact that the rate of GHG emissions associated with use of electricity will likely decrease with time as the nation heads towards the emission reduction path of 2020. The LCCF calculator has accounted for this decreasing trend through the use of the Common Carbon Metric for Energy and Water.

Transmission Emissions

The use of transport is influenced by a number of factors, including number of parking spaces and distance to mass transit stops. Perhaps the greatest effect a development can have on transport is the provision of a limited number of car parking spaces, bike racks, a shower room for those who bike, and plug-in stations for an emerging fleet of plug-in hybrid electric vehicles. The current version of the LCCF Calculator has accounted for this aspect of emissions. However, more statistical data is necessary to enhance the current calculator.

5.5 Carbon Neutrality

Carbon neutrality is a societal goal of net zero carbon for sustainability assessment. The current version of the LCCF Calculator can be used to calculate carbon neutrality for any development by considering net zero carbon flow.



6 RELEVANT CARBON FACTORS

6.0 RELEVANT CARBON FACTORS

6.1 Urban Environment

UE 1-1 Development within Defined Urban Footprint

Relevant carbon factors:

a. Carbon footprint of the built-up area over the total area of a given development.
b. Carbon emissions from Greenfield, infill, Brownfield and Greyfield growth.
c. Reduction in vehicle miles travelled (VMT)
   VMT can be calculated using the following information attainable from (i) Census or other national data sources or (ii) site specific:
   - Number of vehicles owned per household unit
   - Types of vehicles
   - Trip distance
   - Number of households
   - Number of retail shops, offices and miscellaneous uses and jobs/units

From VMT, the fuel use, GHG and criteria pollutant emissions can be calculated. The GHG emissions are calculated based on per-mile assumptions to VMT.

UE 1-2 Infill Development

Relevant carbon factors:

a. Total area of infill development.
b. Infill and other earthwork activities for development.
c. Reduction in VMT from site to city centre:
   - Infill sites reduce VMT by 39-52% per capita daily VMT (as % of infill/greenfield) (Source: Allen et al, 1999).

UE 1-3 Development within Transit Nodes and Corridors

Relevant carbon factors:

a. Total area of development.
b. Reduction in VMT – through use of public transport as opposed to private motor vehicle reduces VMT by 10%.

   To encourage use of public transport, a development with an existing and/or planned transit service should have at least 50% of dwelling units and non-residential building entrances located within 800-m walking distance of bus and/or tram stops, or bus rapid/light railway /heavy railway transit stations.

UE 1-4 Brownfield and Greyfield Redevelopment

Relevant carbon factors:

a. Total area of Brownfield and Greyfield redevelopment.
b. Remediation works on Brownfield/ Greyfield sites (restoration of sites). Sites may include housing, commercial development or industrial redevelopment.
c. Reduction in VMT:
   - Brownfield sites reduce VMT by 20-40% compared to development in a Greyfield site.

UE 1-5 Hill Slope Development

Relevant carbon factors:
Carbon sequestration by trees/plants
Hilly terrains have minimal impact with respect to GHG emission reduction, but long–term planning is needed to increase the resilience of resources, natural systems and infrastructure to climate change.

To minimise erosion on slopes of undeveloped or previously developed sites, protect habitat and reduce stress on natural water systems with native plants or non-invasive adapted plants. The required restoration for various slopes is shown in Table 6.1 (SSI 2009).

Table 6.1: Slope Restoration

Slope	Restoration
>40%	100%
26-40%	60%
15-25%	40%

UE 2-1 Mixed-use Development

Relevant carbon factors:

a. Total area of mixed-use development.
b. Number of residential units by type and non-residential building (ratio of residential to commercial buildings).
c. Reduction in VMT
   - The integration of land use/transport systems and neighbourhood enhancement provides maximum VMT reductions of 5-10%.

UE 2-2 Compact Development

Relevant carbon factors:
A compact development reduces sprawl through lower density distribution within a dense development when used in conjunction with mixed land use activities, hence placing homes, offices, shops and all other facilities within easy reach.

A compact development can be implemented through intensity development control in commercial, housing, industrial and mixed use developments.

UE 2-3 Road and Parking

Relevant carbon factors:

a. CO_2 released into the atmosphere for the clearing of sites for road and parking facilities.
b. Emissions due to preparation of sites and foundations.
c. Emissions from embodied energy of materials used for road and parking surfaces.
d. Reduced private vehicle dependency and carbon emissions from private transport.

A typical green development limits its road surfaces by not exceeding 20% of the total development area.

UE 2-4 Comprehensive Pedestrian Network

Relevant carbon factors:

a. CO_2 released into the atmosphere for clearing and preparation of sites.
b. Emissions from embodied energy of materials used for the pedestrian network.
c. Reduced private vehicle dependency and carbon emissions from private transport.
d. VMT reduction through pedestrians and cycling = 5% *(Source: pleasantongreenscene.org)*

UE 2-5 Comprehensive Cycling Network

Relevant carbon factors:-

a. CO_2 released into the atmosphere for clearing of sites for cycling network.
b. Emissions due to preparation of sites.
c. Emissions from embodied energy of materials used for the pedestrian network.
d. Reduced private vehicle dependency and carbon emissions from private transport:

Research shows that a VMT reduction of 5% can be achieved as a result of neighbourhood enhancement measures for encouraging walking and cycling *(Source: pleasantongreenscene.org).*

A cycling network should be at least a 5-km continuous network with minimum width of 1.5 m (with kerb).

UE 2-6 Urban Heat Island (UHI) Effect

Relevant carbon factors:
The UHI is a phenomenon where urban areas tend to have higher air temperatures than their rural surroundings as a result of gradual surface modifications including replacement of natural vegetation with buildings and roads.

The GHG related factors associated with UHI include:

a. Carbon sequestration by vegetation/trees to offset carbon emission. Lowering the content of atmospheric carbon, tends to reduce the ambient heat in the air and the surface temperature in the urban landscape and improves the air quality.

As a general rule, a 10% increase in vegetation cover reduces the temperature by about 3 degrees, hence, cooling the ambient temperatures. Maximum mid-day air temperature reductions due to trees are in the range of 0.04 to 0.2°C for every per cent increase in canopy.

Increasing the number of trees to achieve a viable urban tree population is the key to reducing the UHI. The vegetation on streets and albedo (reflectivity) of all urban surfaces shall be as follows:

1. Provide potential cooling by using a combined strategy that maximises the amount of vegetation by:
   - Planting trees along streets and in open spaces;
   - Providing shade to the length of sidewalks on streets through tree canopy;
   - Install an open-grid pavement system that is at least 50% pervious; and
   - Install a vegetated "green" roof for at least 50% of the roof area of all new buildings within the project.

2. Increase albedo through:
   a. Painting buildings and surfaces using paints with solar reflective coatings;
   b. Painting buildings and urban surfaces in light colours to reflect heat; and
   c. Using paving materials of high solar reflective index (SRI) 29 or higher for at least 75% of the roof area of new buildings (LEED ND 2009).

UE 3-1 Preserve Natural Ecology Water Body and Biodiversity

Relevant carbon factors:
Urban biodiversity can be improved through enhancement of existing habitats and creation of new habitats for a green corridor. The Biodiversity Index (CBI) evaluates the ecological footprint of a city. The following GHG related indicators from CBI are used to evaluate the impacts of biodiversity and ecology upon the environment.

a. Indicator 1. Proportion of natural areas of at least 20% of total city area should be covered by natural areas (forest, lakes and wetlands).
b. Indicator 2. Connectivity measures or ecological networks to counter fragmentation.
c. Indicator 9. Proportion of protected natural areas (protected /secured natural areas indicate the city's commitment to biodiversity conservation).
d. Indicator 10. Proportion of invasive alien species (as opposed to native species).
e. Indicator 11. Regulation of quantity of water – proportion of all permeable areas (as in indicator 1) to terrestrial area of city.
f. Indicator 12. Climate regulation: carbon storage and cooling effect of vegetation.

The green open space which promotes wild life conservation and biodiversity includes forest reserves, woodlands, urban forestry, grasslands, wetlands, opens and running water and wastelands.

UE 3-2 Green Open Space

Relevant carbon factors:

a. Increase in green open space results in increase in carbon sequestration.
b. The types and species of trees or vegetation determine the amount of carbon being sequestered.

A typical green development provides at least 10% of green open space over the total development area. The green open space types for use in conjunction with this criterion are defined in Table 6.2:

Table 6.2: Green open space and definitions

Type	Definition	Purpose
Parks and gardens	Include urban parks and formal gardens	• Informal recreation • Community events
Green corridors	Include towpaths along canals and riverbanks, cycle paths and disused railway lines	• Walking, cycling or horse riding • Leisure purposes or travel • Opportunities for wildlife migration
Provision for children And young people	Areas designed primarily for play and social interaction involving children and young people	• Equipped play areas • Ball courts • Outdoor basketball hoop areas • Skateboard areas • Teenage shelters and • 'hangouts'
Outdoor sports facilities	Natural or artificial surfaces either publicly or privately owned used for sports and recreation	• Include school playing fields • Outdoor sports pitches • Tennis courts • Bowling greens • Golf courses • Athletics tracks • Grass playing fields • Water sports facilities
Allotments and community gardens	Opportunities for people to grow their own produce as part of the long-term promotion of sustainability, health and social inclusion. May also include urban farms.	• Growing vegetables and other root crops • N.b. does not include private gardens
Cemeteries & burial grounds	Cemeteries and other burial grounds.	• Burial • Wildlife conservation • Promotion of biodiversity

UE 3-3 Number of Trees

Relevant carbon factors:
Urban environmental quality can be improved through strategic tree planting:-

a. Increase in trees results in increase in carbon sequestration.
b. The types of trees and vegetation determine the quantity of carbon dioxide being sequestered.

The number of trees in cities or developments offers quantifiable benefits as follows:

- Energy conservation: trees provide building shade and mitigate heat island effect, which in turn reduces air conditioning use, electricity costs and air pollution from the generation of electricity.
- Reduction in atmospheric carbon dioxide as trees absorb carbon dioxide
- Storm water control: Trees reduce the amount and flow of storm water in urban areas and thus reduce the need for management infrastructure.
- Air quality: Urban trees filter pollutants as part of their transpiration process, and lower temperatures also reduce the formation of smog.

The rate of carbon sequestration depends on the growth characteristics of the tree species, the conditions for growth and where the tree is planted. It is greatest in the younger stages of tree growth, between 20 and 50 years. The amount of CO_2 sequestered in a tree can be estimated given the tree's age, trunk diameter and height.

6.2 Urban Transport

UT 1-1 Single Occupancy Vehicle (SOV) Dependency

Relevant carbon factors:

a. Average number of private vehicles within the township as derived from national statistics.
b. Average travel distance per day based on a detailed traffic assessment study of the township.
c. Type of fuel used based on national statistics on petrol and diesel vehicle ratio.
d. Average engine size of vehicle based on national statistics from sale of motor vehicles.

The carbon emission baseline can be determined from the local carbon content of fuel used (petrol and diesel) and actual quantity combusted during travel.

Other factors affecting carbon emissions include:

(i) The estimated consumption of fuel based on vehicle manufacturer's declaration of the average engine sizes referred to in item (d); and
(ii) The actual type and number of buildings within the given township has a direct effect on communal emissions.

UT 2-1 Public Transport

Relevant carbon factors:

a. Select a mass public transport system instead of private vehicle travel (behaviour change).
b. Reduce GHG in comparison to private vehicle travel per person on each kilometer travelled.
c. Reduce the length of each trip by planning travel requirements.
d. Reduce the number of trips by consolidating activities to be covered in one trip.
e. Keep check on individual GHG per capita emitted.

The baseline carbon value is based on the total reduction of carbon emissions as a result of increased walking, cycling, riding in 'clean fuel' powered vehicles as well as 'clean fuel' powered mass transport systems. Other factors to be considered:

1. Types of public transport available based on actual location demographics.
2. Types of feeder transport service to public transport terminals based on actual location demographics.

UT 1-1 will form the baseline calculation of the conventional transport system while the mix of private to public transport can be monitored by a comparison between UT 1-1 and UT 2-1.

UT 2-2 Walking and Cycling

Relevant carbon factors:

a. Switch from conventional private vehicles to low emission private vehicles as a means of daily travel, for a start, if public transport is not an option.
b. Switch from low emission private vehicles to 'zero' emission private vehicles as a means of daily travel as a continuing effort, if public transport is not an option.
c. Switch from conventional public transport to low emission public transport as a means of daily travel for a start.
d. Switch from low emission public transport to 'zero' emission public transport as a means of daily travel as a continuing effort.

The baseline is based on the initial initiative of using clean, drop-in replacement fuels such as biodiesel and ethanol for fossil based diesel and petrol, respectively. The progressive change should be towards hybrid, clean fuel vehicles until zero emission vehicles using compressed air, hydrogen fuel cells or MSW biogas. Other factors to be considered are:-

1. Total VMT (based on national statistics).
2. Carbon impact of conventional private vehicles based on UT 1-1.
3. Carbon impact of low or zero emission private vehicles compared to item 2 above.
4. Carbon impact of conventional public transport compared to UT 1-1.
5. Carbon impact of low or zero emission public transport compared to item 4 above.

An approach of a gradual increase from low to zero emission vehicles should be adopted in order to gain 'acceptance' or 'buy in' from the community. Awareness and encouragement by choice should be propagated for passengers travelling by public transport; in the selection of low or zero emission public transport over conventionally powered public transport systems.

UT 3-1 Low Carbon Public Transport

Relevant carbon factors:

a. Shifting preference from conventional energy in the form of coal-fired electricity or fossil fuel diesel to solar or biomass electricity or biodiesel.
b. Produce biogas from MSW (municipal solid waste) to power mass public transport vehicles to lower further the carbon impact by disallowing the MSW to go to dumping grounds or sanitary landfills.
c. The progress then must be towards hybrid, clean fuel vehicles till the achievement of zero emission vehicles using compressed air, hydrogen fuel cells, etc.

The baseline is based on the initial initiative of using clean, drop-in replacement fuels such as biodiesel and ethanol for fossil based diesel and petrol respectively. The progressive change should be towards hybrid, clean fuel vehicles and eventually, zero emission vehicles using compressed air, hydrogen fuel cells or MSW biogas. Similarly, electric powered public transport can shift from coal-fired electricity to solar or biomass generated electricity.

Other factors to be considered are:

a. Total VMT (based on national statistics).
b. Carbon impact of conventional public transport compared to UT 1-1.
c. Carbon impact of low emission public transport compared to item 2 above.
d. Carbon impact of clean fuel public transport compared to item 2 above.

A gradual increase from low to zero emission public transport should be adopted in order to gain 'acceptance' or 'buy in' from the community. Awareness and encouragement by 'choice' should be propagated for passengers travelling by public transport; in the selection of conventionally powered public transport systems over a 'clean fuel' powered public transport system.

UT 3-2 Low Carbon Private Transport

Relevant carbon factors:

a. Switch from conventional private vehicles to low emission private vehicles as a means of daily travel for a start if public transport is not an option.
b. Switch from low emission private vehicles to clean fuel powered private vehicles as a means of daily travel as a continuing effort, if public transport is not an option.
c. Ensure the systematic conversion of all means of private transport to clean fuel.

The baseline carbon value is based on the initial initiative of clean, drop-in replacement fuels such as biodiesel and ethanol for fossil based diesel and petrol respectively. The progress then must be towards hybrid, clean fuel vehicles using compressed air, hydrogen fuel cells or MSW biogas. Similarly, electric powered private vehicles

can shift from coal-fired electricity to solar or biomass generated electricity.

Other factors to be considered are:
1. Total VMT (based on national statistics).
2. Carbon impact of conventional private vehicles as in UT 1-1.
3. Carbon impact of low emission private vehicles compared to item 2 above.
4. Carbon impact of clean fuel private vehicles compared to item 2 above.

A gradual increase from low emission private vehicles to clean fuel vehicles should be adopted in order to gain 'acceptance' or 'buy in' from the community. Awareness and encouragement by 'choice' should be propagated for vehicle owners travelling by private transport; in the selection and purchase of conventionally powered private vehicles over 'clean fuel' powered private vehicles.

UT 4-1 Vehicle Speed Management

Relevant carbon factors:
a. The optimum speed versus consumption of fuel for the different categories of engine size (based on vehicle manufacturer's statistics).
b. The type of fuel used against the number of vehicles on the road (based on national government statistics).

The baseline carbon value is based on all motorised vehicles maintaining a pre-determined speed for optimum consumption, compared to excessive speeds that consume more fuel and subsequently, emit more carbon over any given distance. This approach ensures that vehicles are able to travel at an optimum speed at any given time of day. In order to address this need, a flexible system of speed moderation should be implemented.

UT 4-2 Traffic Congestion and Traffic Flow Management

Relevant carbon factors:
a. Statistics on the duration of occurrence of traffic jams.
b. Statistics on an estimated number of vehicles involved in jams.

The baseline carbon value is based on the total reduction of carbon emissions as a result of smooth flow of traffic at any given time and within the optimum speed compared to increased emissions caused by low engine idling speeds in traffic jams.

The gathering of statistics peculiar to a particular township should be carried out on a 'best effort' basis as this is the key to reducing the carbon footprint of vehicles travelling at an optimum speed, avoiding traffic jams and improving traffic flows.

6.3 Urban Infrastructure

UI 1-1 Land Take for Infrastructure and Utility Services
Relevant carbon factors:
1. Avoid multiple underground routes which will result in higher carbon count from an 'embodied energy' perspective.
2. Ensure future expansion is convenient and with minimal impact and disruption. This will in turn reduce the carbon footprint of the scope of work for any expansion and/or upgrade required.

The baseline carbon emission is based on the total embodied carbon of a 'multiple utility routes' system. The difference between the embodied carbon value of a 'multiple utility routes' system and 'common utility route' system will result in the carbon abatement quantity. Another factor to be considered is repetitive excavation work during the life span of the township.

The carbon abatement value of this criterion can serve as a guide only as it cannot be calculated in a tangible manner unless done in retrospect.

UI 1-2 Earthwork Management

Relevant carbon factors:
a. Diesel driven earth moving and grading vehicles required to cut and fill the site will contribute to carbon emissions.
b. Transporting the earth out (in the case of 'fill') and importing earth (in the case of 'cut') by lorries and dump trucks also contribute to carbon emissions.

UI 1-3 Urban Storm Water Management and Flood Mitigation

Relevant carbon factors:
Storm water management activities and systems entail energy consumption or greenhouse gas emissions. However, use of alternative storm water management approaches has several benefits to climate change and flood mitigation. The GHG related factors associated with storm water management include:

a. Pumping of storm runoff consumes energy. In communities where storm and sanitary sewers are combined, sending storm water into the system may increase the energy needed to pump and treat wastewater. Therefore capturing, treating and reusing runoff on a site may help reduce potable water consumption on a site, leading to reduced public and private utility costs and energy expenditures for pumping, cleaning and processing water.
b. By retaining water on site, this will cut down discharges to storm water management systems, which in turn can reduce combined sewer overflow and mitigate flooding and avoid adverse effects on aquatic habitat.

This effort can also lead to reduced infrastructure requirements for storm water collection and treatment, hence saving energy and GHG emissions that would have been needed for construction. Alternative designs that mimic natural hydrological patterns reduce the overall impacts of traditional storm water infrastructure.

The use of integrated storm water management planning will help to achieve multiple objectives and minimise environmental impacts. Surface runoff can be reduced as follows:

- Infiltration systems and pervious paving can reduce or eliminate runoff from sites.
- Trees and vegetation (e.g. urban forests) provide an evapo-transpiration function that can reduce runoff.
- Utilising captured rainwater or storm water for non-potable water uses (such as irrigation) reduces runoff and consumption of potable water.

UI 2-1 Construction and Industrial Waste Management

Relevant carbon factors:

a. Stop open burning of wood and other combustible waste.
b. Ensure most construction waste ends up in landfills or dumpsites.
c. Reduce 'export' transport carbon footprint by reusing construction and industrial waste as much as possible.

The baseline carbon value is based on the environmental impact of all construction waste and industrial waste of every development from the construction stage until completion. This waste impacts the environment in several ways. Firstly, the transport of the waste from the site has a carbon footprint. Secondly, the bio and photo degradation of the non-recycled waste is the biggest contribution in terms of carbon emissions. Lastly, there exists a possibility of burning the waste on site. Although this is closely monitored, the penalty may not be a deterrent.

If all the waste is segregated into one part of waste that can be recycled and another part which cannot be recycled, then a large part of the total carbon emissions as mentioned above may be abated. The recyclable waste is sold to recyclers while the non-recyclable waste can be converted into energy and compost. The calculator must have information on the quantity of waste and type of waste received which can be achieved by implementing a site-wide waste management system.

UI 2-2 Household Solid Waste Management

Relevant carbon factors:

a. Sorting and segregation of waste into recyclable (largely inorganic) and waste that can be biogasified allows the waste to be treated in the respective methods of recycling and biogasification.
b. Conversion of organic waste to biogas stops the waste being deposited in dumpsites and sanitary landfills.
c. Biogas can be utilised for cooking, powering of vehicles (with minimum modification) or generation of electricity.

The carbon baseline is derived by calculating the amount of carbon that is emitted from the waste if allowed to go to sanitary landfills. The abated carbon is the difference between that total and the carbon footprint of the waste if it is segregated then recycled and biogasified respectively, as well as the new energy created instead of importing fossil based fuels which can contribute to an even larger carbon footprint.

Statistics of quantities, qualities and proportions of organic compared to inorganic waste are extremely important to a well-balanced energy mix to be produced.

UI 3-1 Energy Optimisation

Relevant carbon factors:

a. Primarily, the forms of energy relevant to the purposes of this document are electricity, cooking gas (butane) and fuel (petrol and diesel).
b. Through knowledge and simulation, the use of all forms of energy can be optimised.
c. Using technology, the consumption of the optimised energy can be further reduced.

The baseline carbon footprint can be calculated by total energy consumed (using conventional energy) in any development, irrespective of whether it is during the construction phase or the operation stage. Implementing items (b) through (c) above can abate a significant amount of carbon.

UI 3-2 Renewable Energy

Relevant carbon factors:

a. Low carbon fuels, such as biogas and biodiesel, to replace fossil fuels.
b. No-carbon energy sources such as wind and solar will also contribute to lower carbon footprint using alternative energy sources.

The baseline carbon footprint can be calculated by total energy consumed (using conventional energy) in any development, irrespective of whether it is during the construction phase or the operation stage. Implementing items (a) and (b) above can abate a significant amount of carbon.

UI 3-3 Site-Wide District Cooling System

Relevant carbon factors:

a. District cooling is the distribution of cooling from one or more sources to multiple buildings. District cooling systems produce chilled water at a central plant and then pipe that energy out to buildings in the area for air conditioning use. It reduces energy use and adverse energy-related environmental effects. District cooling has been proven to be a major contributor to greenhouse gas reduction in many cases.

b. District cooling systems displaces peak electric power demand with district cooling and storage using ice or chilled water. This benefits the local power grid by reducing peak power demand and alleviating power congestion due to power transmission limitations in cities. Therefore, district cooling not only helps cool cities; it helps alleviate the challenges posed by high electricity consumption.

District cooling is now widely used in downtown business districts and institutional settings such as college campuses. Individual buildings no longer need their own chillers or air conditioners.

UI 4-1 Efficient Water Management

Relevant carbon factors:

a. Treated water has a carbon footprint derived from the treatment method (filtration, chlorination, etc).
b. The transport of this water through electric pumps from source to consumer also contributes to another carbon footprint.
c. Reuse of treated water (grey water) and recovery of non-treated water (rainwater harvesting) will lower the carbon footprint of water use.

The total amount of treated water consumed in any township development (during construction as well as operations), considering the factors stated in items (a) and (b) above, gives the baseline carbon footprint. Utilising methodologies stated in item (c) above as well as other technology contributions such as low flow sanitary fittings can lower this footprint.

6.4 Buildings

B1-1 Operational Energy Emissions

Relevant carbon factors:

a. Operational energy emissions are the result of the provision of thermal comfort, indoor air quality, lighting and electricity for plug loads. The operational stage typically represents the greatest portion of carbon flow throughout a building's life cycle. The carbon emission associated with building operations is approximately 80% of the total energy consumption (UNEP 2010).
b. GHG emissions can be reduced through the use of low carbon buildings (LCB). Careful design of the building form and construction combined with energy efficient appliances, highly efficient heating and cooling systems and use of renewable energy will reduce energy demand and GHG emissions.
c. Baselines and benchmarks established through the Common Carbon Metric (CCM) enables building performance to be measured, reported and verified consistently through metrics based on building type, age and local climate. The CCM is a performance based standard that identifies and sets benchmarks in arriving at a targeted climate goal. An example of CCM for operational energy for building typologies in Putrajaya is shown in Table 6.3.
d. Low carbon buildings reduce their GHG emissions during operation strategically through reduced energy consumption and switching to renewable energy sources. Low carbon skills extend beyond design; they should be embedded within communications, procurement and project management activities to ensure that the quality of the low carbon design is reflected in the resulted building.

B1-2 Operational Water Emissions

Relevant carbon factors:
Water-related GHG emissions result from two main categories of energy use:

a) System uses, including the transport, treatment and distribution of water consumed.
b) Consumption of water from end users which is dependent upon number of users or building occupants.

The GHG emission for water supply and delivery for Putrajaya is 0.419 kg/m^3.

B 1-3 Emission Abatement through Retrofitting

Relevant carbon factors:

a. Carbon emissions from reduced electricity consumption in retrofitted buildings.
b. Carbon emissions from reduced operational water

Table 6.3: Common Carbon Metric for Building Typologies

Building Type	CCM kgCO2e/m2/yr
Offices (government)	137
Residential	
• Bungalow	59
• Residential - semi-detached	39
• Residential -terrace	16
• Residential - apartment/ condominium	22
• Residential - affordable homes	42
Hospital	242
Hotel	354
School	29

consumption in retrofitted buildings as a result of water-efficient technologies and features. The indoor water use and energy in buildings undergoing major renovation must be less than in baseline buildings.

B1-4 Building Orientation

Relevant carbon factor:
Building orientation affects air conditioning and heating energy requirements through:

a. Solar radiation, which has heating effects on walls and rooms.
b. Ventilation, which is associated with the direction of prevailing winds and building orientation.

In hot humid climates, the solar influence on energy consumption in buildings is significant; therefore design strategies are focused on reducing heat gain.

Solar heat gain can be reduced by:

1. Designing and orienting 75% or more of the project's total building area (excluding existing buildings) such that one axis of each qualifying building is at least 1.5 times longer than the other, and the longer axis is within 15 degrees of geographical east-west. Solar-oriented buildings with a longer axis (at least 1.5 times length of other axis) within 15 degrees of geographic east-west *(Source: LEED ND 2009)*, or simply orientate the largest wall areas in the north-south direction.
2. Land lots should also be orientated similar to buildings in order to maximise land use for passive design (Aynsley):
   - Lots facing a street running east/west should have long frontage and less depth while lots facing a street running north/south should have fewer frontages to the street and greater depth.
   - Lots facing a street aligned northwest/southeast or northeast/southwest should have equal frontage and depth to allow steps in external walls which provide self-shading to walls from the low angles of the afternoon sun, or rotation of the house plan to orientate long walls to the north and south.

Other design strategies for reducing heat gain include:

- Shading east-west facing walls with large roof overhangs or plant shade trees in front of them.
- Locating service areas such as staircases, store rooms and service ducts in the east-west external walls.
- Placing service or unoccupied rooms on the floor immediately below roof top to reduce solar gain through the roof.

B2. Community Buildings

B2-1 Shared Facilities and Utilities within Building

Relevant carbon factors:

1. Reduce emissions through shared community service facilities with other building use.
2. Save land use and development on Greenfields.

7

THE LCCF CALCULATOR USER GUIDE

7.1 Using the LCCF Calculator

The calculator uses EXCEL spreadsheets to analyse baselines and CO_2 reduction of the performance criteria. It can be used to evaluate the performance of a new development, existing cities and regeneration projects.

The LCCF Calculator assesses each criterion in terms of CO_2 emissions and CO_2 sequestration/absorption.

The results are available in tabular form and show real time changes as the user adjusts the inputs. This allows different criteria options to be considered in the light of their environmental impacts and provides the information necessary to make informed, scientifically based choices.

Step 1
Take note of the colour codes.

Legend	
	Input data in yellow cells
	Development details and calculations
	Benchmarks details and calculations

Figure 7.1: Colour Codes for LCCF Calculator

Step 2
Input information on development details and your organisation.

Step 3
Select sheet from the following elements:

- Urban Environment (UE)
- Urban Transport (UT)
- Urban Infrastructure (UI)
- Buildings (B)

Criterion designation:

Urban Environment	:	UE 1-1 to UE 3-3
Urban Transport	:	UT 1-1 to UT 4-2
Urban Infrastructure	:	UI 1-1 to UI 4-1
Buildings	:	B1-1 to B2-1

Step 4
A sample of the LCCF Calculator spread sheet is shown in Figure 7.1. Complete each sheet of the criteria highlighted in step 3 by filling in the column in yellow. The results of the calculation are shown in green. Benchmarks and standards and other default values are shown in pink. The following is a sample of the LCCF Calculator spread sheet.

LOW CARBON TOWNSHIP ASSESSMENT SYSTEM

Greenhouse gas (GHG) Emissions Calculator

Legend

Input data in yellow cells
Development details and Calculations
Benchmarks details and calculations

URBAN TRANSPORTATION				
UT 4-2	Baselines emissions	Project emissions	Reduction in C02	% reduction C02/total C02
UT 4-2 (tC02/yr)	79.20	69.22	9.98	12.60

UT 4: TRAFFIC MANAGEMENT

UT 4-2: Traffic congestion and traffic flow management

The aim of this criteria is to Ensure smooth flow of traffic throughout the development, irrespective of peak hour or off peak hour.

Types of Vehicles	Total number of vehicles	Total idling time/hour	Fuel consumption at low speed	Total Rolling time/hour	Fuel consumption at average speed	Carbon Abatement (tCO2/yr)
a. motorcycles	10	0.3	0.5	0.3	0.35678756	0.42963732
b. cars	100	0.3	2	0.3	1.7421815	7.734555
c. 4wd/SUV/van	20	0.3	2.5	0.3	2.25266614	1.48400316
d. light trucks	5	0.3	1.8	0.3	1.5813625	0.32795625
e. Lorry (up to 5 tons)						
f. Lorry (above 5 tons)						
Total (tCo2/yr)			**79.2**		**69.22384827**	**9.97615173**

Figure 7.2: Sample of LCCF Spreadsheet

7.2 LCCF Summary Sheet

A summary page in the EXCEL spreadsheet shows the amount of CO_2 emissions and percentage of CO_2 reduction of the project for the respective criteria. A sample of the summary sheet is shown in Figure 7.3

The sum of CO_2 reduction over the baseline emission awards the development with the corresponding environmental performance achievements according to the 'diamond' rating as defined and classified under the LCCF Calculator (Table 7.1).

Projects can be assessed through (i) a holistic approach with assessment of all 4 elements (UE, UT, UI and B) or (ii) selected elements from UE, UT, UI and B.

Summary Sheet

Criteria	Sub Criteria		SUMMARY - TOTAL CARBON EMISSIONS(tCO2/yr)			% reduction achieved	Remarks
Urban Environment			Baseline	Project	Reduction		
UE 1: Site Selection	UE 1-1	Development within defined urban footprint					
	UE 1-2	Infill development within existing urban footprint					
	UE 1-3	Development within transit nodes and corridor					
	UE 1-4	Brownfield and Greyfield redevelopment					
	UE 1-5	Hilly slope development					
UE 2: Urban Form	UE 2-1	Mixed - use development					
	UE 2-2	Compact development					
	UE 2-3	Road and parking					
	UE 2-4	Comprehensive Pedestrian Network					
	UE 2-5	Comprehensive Cycling Network					
	UE 2-6	Urban heat island effect (UHI)					
UE 3: Urban Greenery and Environment Quality	UE 3-1	Preserve Natural Ecology, Water Body and					
	UE 3-2	Green Open Space					
	UE 3-3	Number of trees					
Urban Transportation							
UT 1: Shift of Transport Mode	UT 1-1	Single occupancy vehicle (SOV) dependency	8062.74	6332.50	1730.23	21.46	
UT 2: Green transport Infrastructure	UT 2-1	Public Transportation	8062.74	5762.74	2300.00	28.53	
	UT 2-2	Walking and cycling	5.93	0.00	5.93	100.00	
UT 3: Clean Vehicles	UT 3-1	Low Carbon Public Transportation	8.18	0.00	8.18	100.00	
	UT 3-2	Low Carbon Private Transportation	5.93	3.07	2.86	48.26	
UT 4: Traffic Management	UT 4-1	Vehicle speed management	6.80	5.93	0.87	12.75	
	UT 4-2	Traffic congestion and traffic flows management	73.20	63.22	9.98	12.60	
Urban Infrastructure							
UI 1: Infrastructure Provision	UI 1-1	Land take for infrastructure and utility services	7.00	3.50	3.50	50.00	
	UI 1-2	Earth works management	1.00	0.50	0.50	50.00	
	UI 1-3	Urban stormwater management and flood mitigation	1.00	0.50	0.50	50.00	
UI 2: Waste	UI 2-1	Construction and Industrial Waste management	8.00	4.00	4.00	50.00	
	UI 2-2	Household Solid Waste management	8.00	4.00	4.00	50.00	
UI 3: Energy	UI 3-1	Energy Optimisation	1.27	1.21	0.07	5.16	
	UI 3-2	Renewable Energy	1.27	0.53	0.74	58.45	
	UI 3-3	Site wide district cooling system	730.00	660.00	70.00	9.59	
UI 4: Water management	UI 4-1	Efficient Water Management	1.33	0.95	0.38	28.77	
Buildings							
B 1: Low Carbon Buildings	B 1-1	Operational energy emissions					
	B 1-2	Operational water emissions					
	B 1-3	Emissions abatement through retrofitting					
	B 1-4	Building orientation					
B2: Community Buildings	B 2-1:	Shared facilities and utilities within building					
		Total Overall Score				42.22	Best practice 3 (BP3)

Figure 7.3: Sample of Summary Sheet

Table 7.1: Rating System

Carbon Reduction Level	Level of Achievement
100	Carbon Neutral
70 - 99%	Best Practice 5
50 - 69%	Best Practice 4
30 - 49%	Best Practice 3
10 - 29%	Best Practice 2
1 - 9%	Best Practice1

APPENDICES

APPENDIX 1
Guide to Setting a Road Map

What Is a Roadmap?

Today, going green is no longer an option, but rapidly becoming an imperative. This is why there is a need to set up a road map. A roadmap is typically less detailed, and includes the preparation of a master plan as a basis towards making a city greener. In preparing a road map of a city, a working group should be set up to include participatory effort from various parties such as the government, local community and developer. They need to work together and create a roundtable discussion with the aim of looking at all aspects to achieve a green city.

On the way to becoming a green city, a road map can be a useful tool where it provides guidance on implementation. It also allows a quick start to a journey to achieve a specific goal. As many parties are involved, it helps to accomplish the target or goal because it displays an illustrative high level plan of a project.

The Importance of a Road Map

There are various kinds of road maps from multidisciplinary fields. It can be a road map for integrated building design, for green growth, for green economy and more. A road map is important because:-

i. It gives a clear direction towards achieving the goal or target so that the working group know the city's current condition or stage and what needs to be done;
ii. It helps to strategize the step by step work flow. A road map will have key milestones to indicate the stage of progress;
iii. It creates a healthy competitive green effort among cities and helps expand existing green programmes;
iv. It encourages a city's transition into becoming a green city; and
v. It helps in better coordination and cooperation between stakeholders and local, state and federal agencies.

Steps in Preparing a Road Map

In producing a road map, there are some necessary steps, namely:-

A Template of Green City Initiative Road Map

As discussed previously, a comprehensive road map needs collaboration among various parties. It is a tool where the city dwellers know the city's visions for growth and development. As an example, a Road Map of Solid Waste Reduction can be used. The flow of the road map is as below:-

i. Determine a Vision

A vision ought to be simple yet clear enough to make it easier to understand. It must have a target number and target year to achieve.

For the Road Map of Solid Waste Reduction, the vision is to reduce solid waste generation in the city by 10% in 2011.

ii. Define Objectives

Objectives are set to be methods in achieving the vision. They can be few or many, as long as they are tied with the vision.

Several objectives have been identified to achieve 10% reduction of solid waste. Those objectives are:
- To reduce the amount of solid waste collected in a city despite an increase in population;
- To increase the volume of recyclables from all households, offices, institutions & commercial premises;
- To increase the life span of landfills;
- To encourage the 3Rs throughout the city; and
- To engage the private sector and communities.

iii. Justify the Objectives

To make the above objectives seem achievable, it is important to justify all the possible actions that can be addressed. Justifications for all the objectives are:-
- A need to reduce solid waste that goes into landfills;
- Reduction in GHG generated from waste and landfills;
- Reduction in operational costs in solid waste collection;
- Reduction in maintenance costs for the city;
- Generation of compost for gardens;
- Generation of community activities from recycling activities; and
- Fostering of partnerships among all stakeholders towards attaining a greener city.

iv. Set Targets

There are two targets:-
- To reduce solid waste by up to 10% within 12 months; and
- To increase total recyclables collected by 10%.

v. Determine Baseline Data Requirements

Database is crucial as it provides information for reference and for future review. It helps in research and development (R&D) of a project. Baseline data required for a solid waste reduction road map consists of:-
- Total tonnage of solid waste collected in the city (2005-2009);
- Per capita of solid waste collected (2005-2009);
- Total tonnage of recyclable solid waste collected;
- Total expenditure on solid waste collection per year (2005-2009);
- Number and location of recycling bins; and
- Routing of waste collection trucks and frequency of collection.

vi. Establish Partners and Identify the Roles

Establishing partners is crucial not only to create a strong working group but also to improve on the road map.

In the case of the Roadmap of Solid Waste Reduction, there can be nine identified partners:-
- Alam Flora;
- Residents' associations;
- Schools;
- Recycling company/ industry players;
- Developer;
- Media;

- Local business association;
- Waste Management Association of Malaysia; and
- Other NGOs.

Each partner has a role in the road map:
- Leadership;
- Research and demonstration;
- Commercialisation;
- Education and inspiration;
- Legislation, regulation, enforcement; and
- Investments and initiatives.

vii. Identify Pilot Areas and their Attributes

Before commencing on a project, the working group needs to identify the pilot area/s and some basic data:

In the example of the solid waste reduction road map, the target areas are Precinct 8 and Precinct 9 of Putrajaya. The basic data requirements are:-
- Total number of households;
- Total population;
- Number of schools;
- Number of commercial premises; and
- Availability of parks and gardens / areas for community composting project.

Each area or site has its own strengths. In order to recognise the strengths, the working group has to:-
- Undertake a SWOT analysis of the pilot project area in terms of physical, social, environmental assets; and
- Review or endorse the pilot project area.

Requirements

Prior to embarking on the road map, the accounting items should be included to determine whether the road map seems realistic or otherwise. Factors such as expenses, sponsorship, costs and revenue must be incorporated into the road map. With the solid waste reduction road map as example, the required actions are:-

i. Expenses on Pilot Project
- Publicity;
- Meetings and public engagement;
- Additional recycling bins;
- Rewards and incentives;
- Launch campaign;
- School competitions; and
- Miscellaneous.

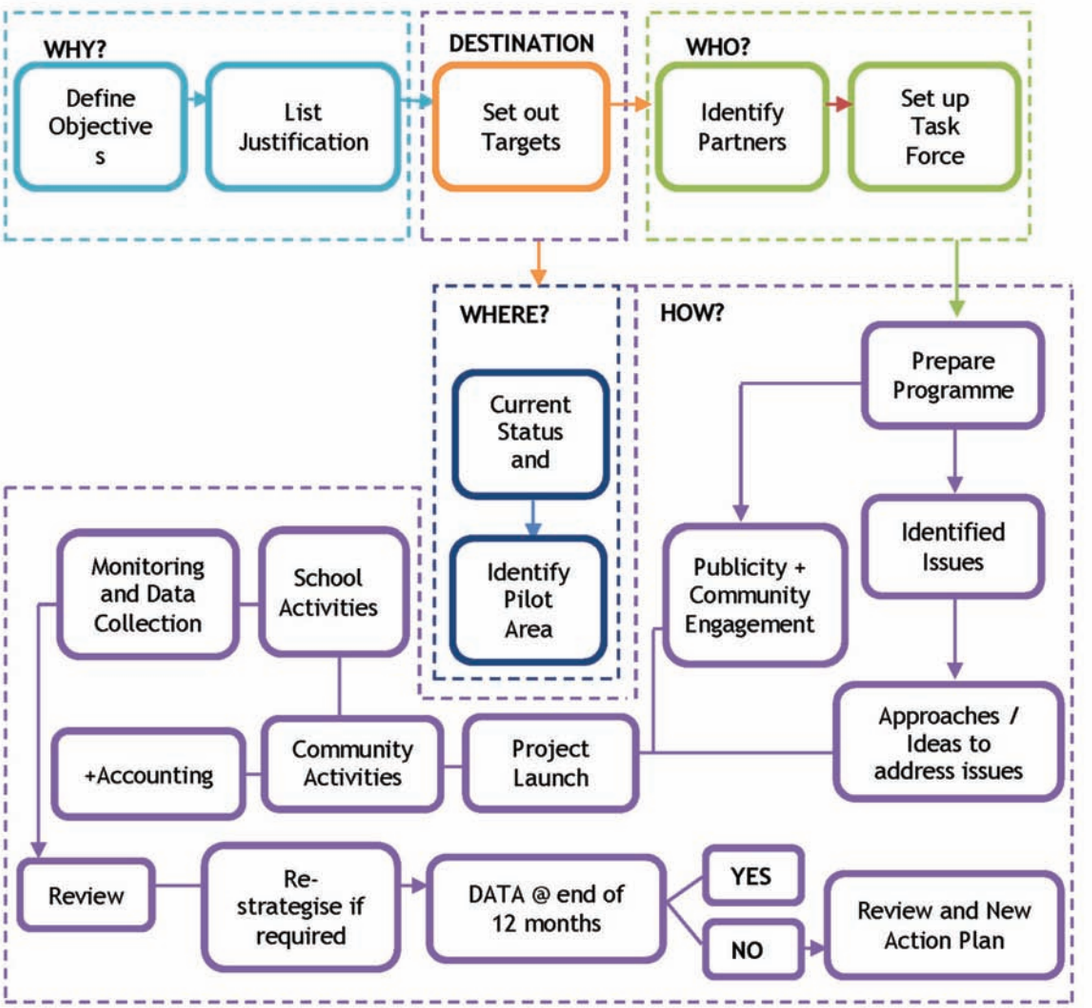
ii. Sponsorship
- Developer;
- Media; and
- Other sources.

iii. Cost Savings from Reduction in Solid Waste
- Cost savings from collection operations;
- Cost savings from maintenance operations; and
- Savings of GHG in tons.

iv. Revenue from Waste Recyclables
- Compost; and
- Byproducts from recycled materials.

Action Plan and Timeline

An action plan and timeline are strongly needed in developing a road map. With the existence of these two vital components, the road map will seem realistic and achievable. The following is a diagram of an action plan that lists out the step by step actions.



Besides preparing the action plan, it is also crucial to set a timeline for the road map so as to assess its effectiveness, whether it is achievable within the time set or not. The table below shows an example of a timeline that can be applied for any road map for a greener city.

GLOSSARY

GLOSSARY

COMPONENT	DESCRIPTION
Activity Data	Data on the magnitude of a human activity resulting in CHG emissions. Data on energy use, miles travelled, input material flow and product output are all examples of activity data that might be used to compute CHG emissions. *(Source: UNEP SBCI – Sustainable Buildings and Climate Initiative, 2009)*
Abatement	Reducing the degree or intensity of greenhouse gas emissions. *(Source: unfccc.int/essential_background/glossary/items)*
BAU (Business-As-Usual	A normal execution of standard functional operations within an organisation, particularly in contrast to a project or programme which would introduce change. *(Source: en.wiktionary.org/wiki/business_as_usual)*
Biodiversity	The range of variation found among microorganisms, plants, fungi and animals. Also the richness of species of living organisms. *(Source: www.esa.org/education_diversity/pdfDocs/biodiversity.pdf)*
Brownfield	An area which is abandoned or underused industrial and commercial facilities available for re-use. However, any expansion or redevelopment in this area is complicated due to environmental contamination. *(Source: www.epa.gov/OCEPATERMS/bterms.html)*
Building	Construction work that has the provision of shelter for its occupants or contents as one of its main purposes; usually partially or totally enclosed and designed to stand permanently in one place. *(Source: UNEP SBCI – Sustainable Buildings and Climate Initiative, 2009)*
Carbon Adsorption	Removal of contaminants from ground water or surface water in a treatment system by forcing it through tanks containing activated carbon treated to attract the contaminants. *(Source: www.epa.gov/OCEPATERMS/cterms.html)*
Carbon Footprint	The direct effects that one's actions and lifestyle have on the environment in terms of carbon dioxide emissions. It can be direct or indirect impact in accelerating climate change. *(Source: www.dcnr.state.pa.us/brc/grants/Glossary.doc)*
Carbon Sequestration	Carbon that is removed and stored from the atmosphere in carbon sinks (such as oceans, forests or soils) through physical or biological processes, like photosynthesis. *(Source:www.greenfacts.org/glossary/abc/carbon-sequestration.htm)*
Carbon Stock	The quantity of carbon contained in a reservoir or system which has the capacity to accumulate or release carbon. *(Source:www.greenfacts.org/glossary/abc/carbon-stock.htm)*
Carbon Storage	Carbon that is stored within tree tissue (roots, stems and branches). The amount stored will increase as the tree grows and once it dies or decays, the stored carbon will be released back into the atmosphere. *(Source: urbanforest.dehort.org/glossary)*
CCM (Common Carbon Metric)	A tool used to measure, report and verify reductions in a consistent and comparable way in order to support GHG emission reductions through accurate measurement of energy efficiency improvements in building operations. *(Source: www.unep.org/sbci/pdfs/UNEPSBCICarbonMetric.pdf)*
CH_4	Methane, a Kyoto Protocol greenhouse gas. *(Source: UNEP SBCI – Sustainable Buildings and Climate Initiative, 2009)*
CHP (Combined Heat and Power)	An energy conversion process in which more than one useful product, such as electricity and heat or steam, is generated from the same energy input stream (cogeneration). *(Source: UNEP SBCI – Sustainable Buildings and Climate Initiative, 2009)*
Climate Change	Climate change is any long-term significant change in the average weather of a region of the earth as a whole. For more information, see average weather. *(Source: UNEP SBCI – Sustainable Buildings and Climate Initiative, 2009)*
Climate Neutrality	Climate neutrality is a term that refers to an entity with no net GHG emissions. Achieved by reducing greenhouse gas emissions as much as possible and by using carbon offsets to neutralise the remaining emissions. *(Source: UNEP SBCI – Sustainable Buildings and Climate Initiative, 2009)*
CO2 Equivalent (CO2e)	The universal unit for comparing emissions of different GHGs, expressed in terms of the global warming potential (GWP) of one unit carbon dioxide. *(Source: UNEP SBCI – Sustainable Buildings and Climate Initiative, 2009)*
DCS (District Cooling System)	The centralised production and distribution of cooling energy where chilled water is delivered via an underground insulated pipeline to office, industrial and residential buildings to cool the indoor air of the buildings within a district. *(Source: www.empower.ae/php/what-is-district-cooling.php?id=1)*
Emission Factor	GHG emissions expressed on a per unit activity basis. For example, metric tons of CO2 emitted per million Btus of coal combusted or metric tons of CO2 emitted per kWh of electricity consumed. *(Source: UNEP SBCI – Sustainable Buildings and Climate Initiative, 2009)*
Energy Performance	Delivered energy use for building operations, and scope one and two greenhouse gas emissions. *(Source: UNEP SBCI – Sustainable Buildings and Climate Initiative, 2009)*

COMPONENT	DESCRIPTION
Floodplain	An area of low-lying ground adjacent to a river or other type of water body that is subject to flooding. *(Source: www.dcnr.state.pa.us/brc/grants/Glossary.doc)*
GDP (Gross Domestic Product)	The market value of all final goods and services produced within a country in a given period. It is often considered an indicator of the economic health of a country as well as its standard of living. *(Source: www.investopedia.com/terms/g/gdp.asp)*
GFA (Gross Floor Area)	The total floor area contained within a building, including the horizontal area of external walls. *(Source: UNEP SBCI – Sustainable Buildings and Climate Initiative, 2009)*
GHG (Greenhouse Gas)	A gas that contributes towards potential climate change such as carbon dioxide (CO2), methane (CH2) and nitrous oxide (N2O). *(Source: www.epa.gov/OCEPATERMS/gterms.html)*
GHG Inventory	A quantified list of an organisation's GHG emission sources. *(Source: UNEP SBCI – Sustainable Buildings and Climate Initiative, 2009)*
Green Building	Sustainable or high performance building. Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life cycle from sitting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability and comfort. *(Source: EPA, United States Environmental Protection Energy)*
Greenfield	An agricultural, forest or undeveloped land in a city or rural area used for agriculture, landscape design or left to evolve naturally. *(Source: www.businessdictionary.com/definition/greenfield-site.html)*
Grey water	Wastewater that is generated from domestic activities such as laundry, dishwashing and bathing which can be recycled on-site for uses such as landscape irrigation, and constructed wetlands. *(Source: www.greensystems.net/greywater.html)*
Greyfield	Usually former commercial properties which are underutilised or vacant. It can also be an area that was previously developed and is not contaminated. *(Source: www.dcnr.state.pa.us/brc/grants/Glossary.doc)*
GWP (Global Warming Potential)	The ratio of radioactive forcing that would result from the emission of one unit of a given GHG compared to one unit of carbon dioxide (CO2).
HFCs (Hydro-fluorocarbons)	HFCs are Kyoto Protocol greenhouse gases. *(Source: UNEP SBCI – Sustainable Buildings and Climate Initiative, 2009)*
Index	A framework for tracking & reporting building performance over time. *(Source: UNEP SBCI – Sustainable Buildings and Climate Initiative, 2009)*
Infill	New construction or redevelopment of small residential, commercial or industrial properties on previously developed land in cities or developed suburbs. *(Source: www.brownfieldstsc.org/glossary)*
Innovation	A change in the thought process for doing something or new stuff that is made useful. *(Source: UNEP SBCI – Sustainable Buildings and Climate Initiative, 2009)*
IPCC (Intergovernmental Panel for Climate Change)	An international scientific body for the assessment of climate change. The role of the IPCC is to assess the scientific, technical and socio-economic factors relevant to understanding the risk of human-induced climate change. *(Source: www.ipcc.ch/organization/organization.shtml)*
Low Hanging Fruits	Targets or goals which are easily achievable and which do not require a lot of effort. *(Source: www.urbandictionary.com)*
N_2O (nitrous oxide)	A Kyoto Protocol greenhouse gas. *(Source: UNEP SBCI – Sustainable Buildings and Climate Initiative, 2009)*
NGV (Natural Gas Vehicle)	An alternative fuel vehicle that emits less emission compared to other traditional and alternative fuels. It can be used as compressed natural gas (CNG), liquid natural gas (LNG) or even blended with hydrogen. *(Source: www.iangv.org/home.html)*
PFCs (Per fluorocarbons)	PFCs are Kyoto Protocol GHGs. *(Source: UNEP SBCI – Sustainable Buildings and Climate Initiative, 2009)*
Rainwater Harvesting	A method of storing and using rainwater for irrigation and watering plants, washing cars, flushing toilets, supplying washing machines and any other non-potable water uses. *(Source: www.waterbowser-watertank.co.uk/rainwater-harvesting.php)*
SOV (Single Occupancy Vehicle)	A privately operated vehicle whose only occupant is the driver. The drivers of SOVs use their vehicles primarily for personal travel, daily commuting and for running errands. *(Source: en.wikipedia.org/wiki/Single-occupant_vehicle)*
Stakeholder	Any organisation, governmental entity or individual that has a share or an interest in environmental regulation, pollution prevention, energy conservation, etc. *(Source: www.epa.gov/oaqps001/community/glossary.html)*
Sustainable Development	Sustainability is the ability in meeting the basic needs of all and extending to all the opportunity to satisfy their aspirations for a better life without jeopardising the opportunities for future generations. *(Source: www.un-documents.net/ocf-02.htm#I)*

GLOSSARY

COMPONENT	DESCRIPTION
UHI (Urban Heat Island)	The relative warmth of a city compared with surrounding rural areas. This is related to changes in runoff, the concrete jungle effects on heat retention, changes in surface albedo, changes in pollution and aerosols, and so on. *(Source: resilient-cities.iclei.org/bonn2011/resilience-resource-point/glossary-of-key-terms)*
UN (United Nations)	An international organisation that works as central to global efforts in solving problems that confront humanity. It aims at facilitating cooperation in international law, international security, economic development, social progress, human rights, and achievement of world peace. *(Source: www.un.org/Overview/uninbrief)*
UNEP (United Nations Environment Programme)	A designated authority of the United Nations system in environmental issues at the global and regional level. The authorisation is to coordinate the development of environmental policy consensus by keeping the global environment under review and bringing emerging issues to the attention of governments and the international community for action. *(Source: www.unep.org/resources/gov)*
UNFCCC (United Nations Framework Convention on Climate Change)	An international environmental treaty with the goal of achieving the stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. *(Source: unfccc.int/essential_background/convention/background/items)*
Urban Footprint	Amount of space that people use when in public places like sidewalks, exercise paths and public transport (trains, buses, etc.). *(Source: www.urbandictionary.com)*
Urban Forest	All types of vegetation that grow in a city, town or a suburb. In a wider sense, it may include any kind of woody plant vegetation growing in and around human settlements. *(Source: www.definition-of.net/urban+forest)*
VMT (Vehicle Miles Travelled)	A measure of the extent of motor vehicle operation; the total number of vehicle miles travelled within a specific geographic area over a given period of time. *(Source: www.epa.gov/OCEPATERMS/vterms.html)*
Wastewater	Used water which is discharged from the home, community, farm or industry. It contains dissolved or suspended matter that is harmful and damages the water quality. *(Source: www.epa.gov/OCEPATERMS/wterms.html)*
Wetlands	An area that is saturated by surface or ground water with vegetation adapted for life under those soil conditions, such as swamps, bogs, fens, marshes and estuaries. *(Source: www.epa.gov/OCEPATERMS/wterms.html)*

Acknowledgement

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