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# Low Carbon Development through Measuring and Monitoring Carbon Emission in Johor Bahru, Malaysia

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#### **Abstract**

Reducing carbon dioxide emissions through low carbon development is an appropriate solution to combating climate change. This research aims to identify ways of reducing carbon dioxide emissions in Johor Bahru towards promoting low carbon development. The research investigated the low carbon initiatives in Malaysia. The study was based on purposive case study and restricted to Johor Bahru, Malaysia. It reviewed existing practice of low carbon development in the study area. Stakeholders and organizations related to low carbon development and low carbon initiatives were interviewed. The study also observed that the initiative is relatively in the early stage with few projects accomplished. However, emphasis was placed on other themes of low carbon concept rather than direct measurement of Carbon dioxide (CO<sub>2</sub>) emission. Since majority carbon emissions are from electricity and transport sectors, the Malaysian University Carbon Emission Tool (MUCET) was modified and suggested for measuring and monitoring emissions in Johor Bahru. This study facilitates the formulation of policies that target emission reduction and ensure steady movement into clean energy future.

Keywords: Low Carbon Development, Energy Use, Carbon Emission Tool

#### 1 Introduction

Spatial growth and high population in cities are enhanced by the use of energy for movement of goods and services resulting in continuous combustion of fossil fuel based energy. Concentrations of human activities in cities produce emissions of greenhouse gases that accounts for about 78% of carbon emission [1,2]. The current technological practices that favor the use of fossil fuels as major sources of energy [3] are major concerns for carbon emissions. The insatiable energy use for the city's economy to continue to grow under business as usual and the combustion of fossil fuel based energy often results in emissions of CO<sub>2</sub>, which is the major driving force for global warming and responsible for the phenomenal climate change [4].

Climate change is one of the greatest challenges to global development and poses threat to the environment and the global population [5]. The effects of climate change can best be tackled through adaptation of low carbon technology and designing mitigation policies, usually referred to as Low Carbon Development. This may involve implementation of policies on energy sustainability which may bring about changes to the industrial structure and energy mix [6] as well as impact on different sectors and employment structures [7]. Therefore, most nations globally are charting the path to reduce carbon dioxide emission in order to tackle climate change and many cities around

the world have established the development objective to become low-carbon cities.

Low carbon development is very significant to the sustainable development of cities. Over half of the global population resides in cities. This figure would rise to about 70 percent by 2050 [2]. Cities are currently responsible for 67-76 percent of energy use and 71-76 percent of energy related carbon dioxide emissions [4,8]. A major solution to economic growth without increasing carbon dioxide emission is through Low Carbon Development. Therefore, Cities are challenged to go low carbon so as to achieve sustainable development [9], and many cities have established the development objective to become low-carbon.

Low carbon development concept has its roots in the United Nations Forum for Climate Change Convention (UNFCCC) adopted in Rio in 1992. It refers to strategies and growth plans that promote low emission or climate resilient economic growth [10]. Low carbon development refers to a society that emits greenhouse gas (GHG) only in an amount that can be absorbed by nature and portends a movement towards a simpler life style that realizes richer quality of life in coexistence with nature. This means encouraging greenness through new growth, new market and new consumer culture that respects environmentally-friendly technologies by promoting emission reduction strategies and renewable energy use. Low carbon development can be achieved by promoting environmentally friendly activities to tackle the effects of climate

change through adaptation of low carbon technology and by designing mitigation policies so as to achieve sustainable human development [11,12,13]. The most significant question is how the municipal authorities and other stakeholders will intervene to reduce carbon emission with increasing urbanization. The major focus could be on implementation of adopted resolutions of policies designed by Governments and NGOs such as U.N, E.U, A.U among others.

In the light of this, the Prime Minister of Malaysia pledge to reduce the emission intensity of Malaysia by 40% below 2005 level by the year 2020 [14,15]. To achieve this, the government of Malaysia established agencies responsible for the implementation of strategies that will facilitate the achievement of the country's carbon emission reduction goals through the preparation of the blueprint for the promotion of the low carbon society. Notable is the Low Carbon Blueprint for Iskandar Malaysia 2025, which covers five local authorities including the entire district of Johor Bahru and Kulai Jaya. The blueprint recommends 281 strategic policies that would assist to achieve a target of 58 percent reduction in carbon intensity by 2025 compared to 2005 levels [16]. The document was officially launched in 2012 by the Prime Minister of Malaysia and adopted by the Iskandar Regional Development Authority (IRDA).

Reducing carbon dioxide emission from all sectors of human activities to mitigate global warming and combat climate change will require steady monitoring so as to measure and determine the existing levels of CO<sub>2</sub> emission in order to manage and effectively plan the reduction of such emission. The baseline emission for Johor Bahru was determined by the Low Carbon Asia Research Center, Universiti Teknologi Malaysia, UTM, in collaboration with their Japanese counterpart. This measurement and monitoring of carbon emissions was carried out for IRDA using the Asia-Pacific Integrated Model (AIM) [17]. Self-monitoring is very important for administrators to understand the carbon situation and make informed decisions. IRDA needs to monitor emission reduction through its own interface because planning emission reduction becomes easier when familiar variables are considered, more so, people will easily adapt when they know how their footprint was arrived at. Energy has been identified as the driving force for CO<sub>2</sub> emission [13,18]. Promoting low carbon development in Johor Bahru will identify the carbon emission scenario from energy use and adopt a method of assessment to estimate extent of carbon dioxide emission from the sources and facilitate policy formulation based on informed decision.

The purpose of this research is to study how low carbon development is practiced in Johor Bahru and describe a method of carbon inventory to determine  $CO_2$  emission through the assessment of the energy use resources in a manner easier to understand by all stakeholders. This will facilitate the setting and realization of emission reduction targets as well as promote low carbon development in Johor Bahru.

#### 2 Background of Study

Energy is a vital input for social and economic development of any nation [19], and very significant in promoting low carbon development because, energy connects everything to everything else more universally and more quantifiably than any element [20]. Economies of most nations have benefitted from energy resources and it is crucial to a modern economy being a necessary prerequisite for growth and social development. Cities are engines of growth of many nations and ensuring economic growth require the use of energy which is essential for growth and development.

Lifestyles, transportation, domestic energy uses, and consumption, are among the prominent factors that contribute to global warming [21]. Hence, the greenhouse gas emission of a city is a reflection of its structure, energy resources and its resident's lifestyles [12].

Economic development could mean more vehicular traffic movements, more constructions of buildings, more manufacturing and industrial developments, more retail and shopping activities, more concentration of human activities and more energy consumption for transport and electricity. Such thriving economy may bring about growth and socio-economic benefits; usually at the expense of significant environmental impacts through increasing energy demand and rising greenhouse gas emission. Therefore, cities are among the largest contributors of carbon emission where large concentration of human activities impact on the environment having consequences for climate change. Similarly, energy is needed to sustain and expand economic processes like agriculture, electricity, industrial productions, transport and other services, but as energy consumption continues, the threat to global warming also increases, thus, the need to limit the increasing global warming and prevent dangerous climatic change becomes critical [22].

In view of the implication of energy use on climate change, The role of cities in reducing emissions is prominent, since issues of poverty reduction and economic development could be guided by low carbon innovations and emission reduction strategies [5]. Since the kind of technology that fuels the growth of most cities is principally fossil fuel based, therefore cities are central to implementation of low carbon development and as a result, carbon emission becomes a common issue of city sustainability [23,24,25]. Cutting emission may affect economic growth in a hard and difficult way [26], not with standing, taking low carbon development path makes it possible to maintain growth and sustain the living standard while minimizing fossil fuel energy consumption and reducing carbon emissions. In other words, energy is central to economic growth and sustainability and there can hardly be a sustainable city development without sustainable energy development [27].

Furthermore, energy plays a key role in most environmental challenges, therefore, to promote economic growth in the city while reducing carbon intensity, planning the reduction of carbon emission from energy use becomes imperative. It is also essential to find ways and means to reduce the emission of greenhouse gases. towards sustainable development of cities (Sathiendrakumar, 2003). Like most cities, the kind of technology that fuels the growth of Johor Bahru is predominantly fossil fuel based energy whose combustion often results in carbon dioxide (CO2). The need for measurement and cutting carbon emissions is a key challenge, which should focus on achieving energy transformation required to balance economic growth and the environment. This requires scientific analysis regarding the sources of carbon emission and how the emissions can be reduced to achieve low carbon development. Therefore, the sources, type of and energy consumption pattern become central to measuring the extent of CO<sub>2</sub> to achieve sustainable low carbon development in Johor Bahru. Although, there is no existing method of accounting for carbon emissions that accurately reflect "true" emissions levels [20], the best method is one that most encourages reduction of emissions. For that reason, the introduction of an easier method of carbon inventory to determine CO2 in a manner that is understood by the administrators is a key step promote low carbon development through innovative strategies of CO2 emission reduction that facilitates the setting of realizable carbon emission reduction targets from energy use. Consequently, measuring CO2 emission from

energy use will facilitate the determination of extent of emission and ease monitoring through periodical inventory as well as provide the platform for effective management and efficient implementation of emission reduction policies in Johor Bahru.

#### 3 Methodology

A critically review of low carbon initiatives of Malaysia is central to this study. In view of the specialized and technical nature of the study of low carbon developmnt, purposive sampling technique was adopted in the design, selection and collection of data. Sampling was centered on relevant authorities and Information obtained from organizations directly concerned with the management and implementation of related policies. Primary and Secondary types of data were collected from Iskamdar Regional Development Authority (IRDA), Low Carbon Society office, UTM, Sustainable Energy Development Authority (SEDA) and Felda Taib Andak. Also, secondary data were obtained from Taman Nasional Berhad (TNB), Jabatan Pengangkutan Jalan (JPJ), and International Energy Agency (IEA) among others. Since the study was to review existing practice of low carbon development in Johor Bahru, Secondary data were also obtained from relevant published articles like journals, government publications as well as from the internet. Finally, statistical analysis was performed, using descriptive method of analysis, frequency table and charts constructed using computer software (i.e. Microsoft Excel) for easier interpretation and discussion.

#### 4 Low Carbon Development in Malaysian

The 10th Malaysian Plan clearly expressed the aspiration of improving environmental quality by undertaking climate change mitigation, while the sixth strategic thrust of the 11th Malaysian Plan 2016-2020, focused on pursuing green growth for sustainability and resilience by considering four major areas namely:

- Strengthening the enabling environment for green growth.
- Adopting the sustainable consumption and production concept.
- Conserving natural resources for present and future generations, and
- Strengthening resilience against climate change and natural disasters.

The Malaysian government embraced the Low Carbon Society project to ensure that the energy used for development is consumed in an effective and efficient manner without impacting on climate change in the Iskandar Malaysia region in general and Johor Bahru in particular. This is with a belief that encouraging green economy will result in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities [28] and promoting economic growth while reducing carbon intensity. In line with the objectives to promote low carbon development in Johor Bahru, the Malaysian government entrusted onto the Iskandar Regional Development Authority (IRDA), the responsibility of pursuing green growth for sustainability and resilience in the Iskandar Malaysia region. IRDA assisted by the Low Carbon Asia Research Center UTM, Kyoto University, Japan and NIES, JICA, among others developed the Low Carbon Blueprint as a guide to achieve low carbon development in Iskandar Malaysia and show how these can benefit people socially, environmentally and economically. IRDA assists municipal authorities on how to implement low carbon projects and programs through the preparation of local plans and organizing workshops

and also conferences and publications to create awareness in the region.

The blueprint was launched at COP 19 in 2012 [29] and provides the baseline for carbon emission for 2005 to understand the "Business as usual" (BAU) and counter measure scenario. The blueprint has been adopted for the implementation of Low Carbon Society at the 5 local authorities of Iskandar Malaysia and IRDA is monitoring the implementation of the low carbon projects at each of the five local authorities in Iskandar Malaysia. Regarding what has been achieved by low carbon initiative in Johor Bahru, Figure 1 shows the matrix of key actions of the Low Carbon Society Blueprint for Iskandar Malaysia 2025 in relation to IRDA's Implementation Plans 2013-2015. This roadmap includes seven (7) out of the ten (10) implementation Plans of IRDA. The implementation plans are IRDA's initiatives towards a climate resilient economy in Iskandar Malaysia, prepared according to the recommendations of the Blueprint. The implementation plan covers the major themes of the Low Carbon Society concept - Green Economy, Green Community and Green Environment, however, the roadmap did not discuss the three special projects, which require comprehensive study such as Bukit Batu Eco-Community, Low Carbon Village Felda Taib Andak and Nafas Baru, Pasir Gudang. Given the time limit, remarkable progress has been realized towards the low carbon development initiatives in Johor Bahru (Figure 1) and general awareness of the concept has been achieved. In an oral interview, Ho and Boyd [30] opined that the key obstacles to promoting low carbon development is changing the mind-set of those who have not embraced the need to reduce carbon intensity. However, continuous efforts is being made through the initiatives of various stakeholders to achieve the objectives of Low Carbon strategies in Iskandar region in general and Johor Bahru in particular.

### 4.1 Energy Consumption in Johor Bahru

Energy is fundamental to achieving low carbon development. The aspiration of Malaysian Government to encourage economic growth and development in Johor Bahru- a major flagship in the Iskandar Malaysia region would increase the threat to global warming due to increasing energy consumption for economic growth and social development. The first step energy management is to identify the pattern of energy consumption in the city. Johor Bahru offer diverse services for different activities. The extent of CO<sub>2</sub> emission depends on types of service demand and energy requirements. High energy demand service sectors will yield higher CO<sub>2</sub> emission according to the fuel-mix for electricity and fuel types for transport. Figure 2 presents the schematic diagram of the pattern of energy consumption in Johor Bahru. Majority of the sources of energy that drives the growth of the city are fossil fuel based in the form of oil, coal and natural gas among others and constitutes the primary energy. Two principal sources of energy were identified as the generated electricity energy and transport fuel consumption or liquid energy. These represents the set of indicators of carbon emission from which data may be obtained to measure and compare the intensity of emission for various sectors of the city. Energy sustainability requires the inventory of energy consumption pattern as a prerequisite to identify the sectors or types of energy use with high energy demand so as to chart a path for CO<sub>2</sub> emission reduction. The quantification and monitoring of indicators of carbon emission from energy use is desirable to achieve the goals of low carbon development. The values obtained from these sources could be communicated to a range of policy actions towards reducing carbon emission in Johor Bahru. particular.

			Specific Action-based Projects							Special Projects		
IRDA's Implementation Plan 2013-2015  12 Actions in the Low Carbon Society Blueprint for Iskandar Malaysia 2025		GI-1 Green Economy Guidelines for IM	GF2 Portal on Green Technology for Iskandar Malaysia	GB-1 GAIA (Green Accord Initia- tive Award)	GT-1 Mobility Management System	LL-1 Eco-Life Challenge Schools Project	RR-1 Trees for Urban Parks/ Forests	RR-7 Responsible Tourism and Biodiversity Conservation	Bukit Batu Eco-Community	Low Carbon Village Felda Taib Andak	Nafas Baru Pasir Gudang - Clean and Healthy City	
	Action 1 Integrated Green Transportation (GT)											
Green	Action 2 Green Industry (GI)	•										
Green Economy	Action 3 Low Carbon Urban Governance (LG)											
ymo	Action 4 Green Building and Construction (GB)			•								
	Action 5 Green Energy System and Renewable Energy (GE)											
Comr	Action 6 Low Carbon Lifestyle (LL)					•			0	0		
Green Community	Action 7 Community Engagement and Consensus Building (CC)											
	Action 8 Walkable, Safe and Livable City Design (WC)											
Green	Action 9 Smart Urban Growth (SG)											
Enviro	Action 10 Green and Blue Infrastructure and Rural Resources (RR)  Action 11 Sustainable Waste Management (WM)							•		0		
nmen	Action 11 Sustainable Waste Management (WM)											
	Action 12 Clean Air Environment (CA)											

Figure 1: Matrix of relationship between IRDA's projects and policies Source: A Roadmap towards low carbon Iskandar Malaysia. UTM – Low carbon Asia Research Center (2013)

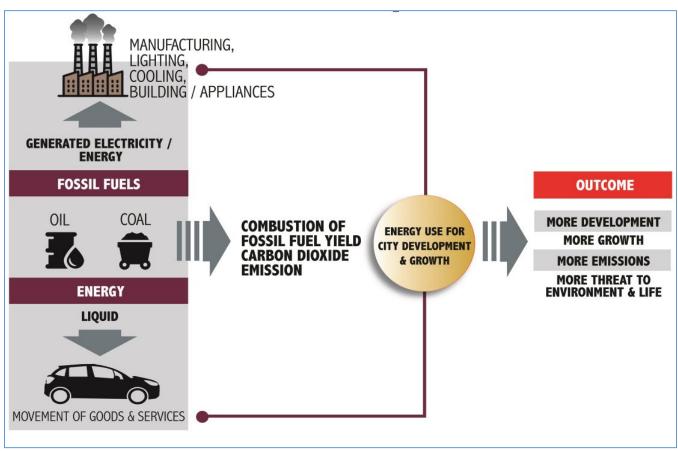


Figure 2: Pattern of Energy Consumption in Johor Bahru (Adapted and modified after Abdul-Azeez, 2015)

The Malaysia electricity generation by fuel (Figure 3) shows that natural gas constitutes the bulk of the fuel mix input while coal and oil remain very significant. Based on this fuel mix the emission factor for Malaysia is given as 0.741 Kg per Kwhr for year 2015 [31]. This figure is universal for electricity consumption in Malaysia peninsular because electricity is generally purchased from a single source, i.e. Tenaga Nasional Berhad (TNB).

Table 1 presents the Carbon Emissions from Fuel Combustion for electricity generation in Malaysian between years 2000 to 2013. The carbon emission from the fuel mix of Malaysian electricity has been rising annually since year 2000. Except for year 2009 where the figure dropped to 168,504.7 Kt CO<sub>2</sub> with emission factor of 0.636 kg of CO<sub>2</sub> per kWh from 189,002 in 2008 with emission factor of 0.696 kg of CO<sub>2</sub> per kWh (Figure 4). The carbon emission picked up again by 2010 and rose to about 82 percent by 2013 with emission factor of 0.693 kg of CO<sub>2</sub> per kWh.

Considering the ambition of Malaysian government to go low carbon, one would have expected the fuel mix of the electricity production to be a major potential for reducing the country's emission. The emission factor for electricity in Johor Bahru depends on the National figure as distributed by Tenaga Nasional Berhad (TNB) - the largest Electric utility company and the main energy provider in Malaysia. This is not steady and has increased by 4 percent above 2005 level (Table 1).

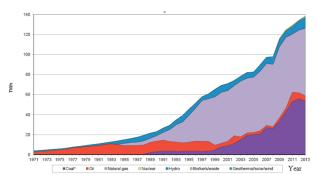


Figure 3: Malaysia Electricity Generation by Fuel (Source: International Energy Agency. http://data.iea.org 2015)

Table 1: Malaysian Carbon Emissions from Fuel Combustion.

Year	Total CO <sub>2</sub> emission- Fuel Combustion (KtCO <sub>2</sub> )	CO <sub>2</sub> per KWh electricity (KgCO <sub>2</sub> /kWh)
2000	114 085.9	540.5
2001	119 360.6	573.5
2002	125 397.8	631.3
2003	131 651.6	579.2
2004	145 308.6	599.2
2005	154 604.7	662.2
2006	160 477.4	640.3
2007	176 723.7	651.2
2008	189 002.8	696.7
2009	168 504.7	636.2
2010	188 405.1	769.0
2011	189 928.1	682.6
2012	191 441.1	681.2
2013	207 248.7	693.1

Source: CO<sub>2</sub> Emissions from Fuel Combustion, OECD/IEA, Paris, 2015

The load growth scenario for Johor Bahru is presented in Table 2. The consumption of electricity energy use is described according to service demand sectors such as electricity use for Domestic, Industrial, Commercial and Street lighting. Energy use by the industries is highest followed by Domestic and Commercial uses, respectively, while Street Lighting has the least consumption of electricity. Determination of extent of CO<sub>2</sub> emission from these sectors can be critical in setting targets for emission reduction in Johor Bahru. Finally, the transition to low carbon societies will not be complete without commitment and leadership from Johor Bahru Municipal authority making local efforts to promote initiatives and measures encouraging energy efficiency, use of alternative fuels, as well as advanced and cleaner technologies among others.

Table 2: Load growth scenario for Johor Bahru in MW

Sector	2010	2013	2015	
Domestic	71.80	85.93	100.06	
Commercial	45.79	59.66	71.19	
Industry	183.41	217.48	251.54	
Street lighting	4.59	5.09	5.47	
Total (MW)	305.59	368.16	428.27	

Source: Johor Bahru City Council (MajlisBandaraya JB-MBJB) 2015.

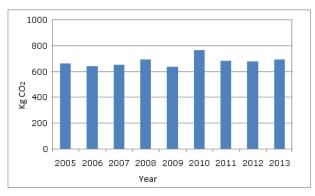


Figure 4: Total CO<sub>2</sub> emission- Fuel Combustion (KtCO<sub>2</sub>) and Emission Factor in Malaysia (i.e CO<sub>2</sub> per KWh) measured in KgCO<sub>2</sub>/kWh (Source: CO<sub>2</sub> Emissions from Fuel Combustion, OECD/IEA, Paris, 2015)

#### 4.2 Transport Energy Consumption in Johor Bahru

There are 21,401,269 vehicles registered in Malaysia by 2013. These include motorcycles, motorcars, buses, taxis, rental vehicles, goods vehicles, excavators, among others. As at 2012, the Federal capital territory of Kuala Lumpur (KL) has 4,963,646 vehicles while. Johor State has a vehicle population of 2,923,898 followed by Selangor with 2,363,333 vehicles. Based on a projected population figure of around 28.725 million the Malaysian person per car ratio of 2.95 persons/car is relatively high (Motor Trader, 2013).

Table 3 shows the types and number of registered vehicles in Johor Bahru. About 90 percent of the vehicles are privately Cars and Motorcycles with 47.2 percent and 43.8 percent respectively. Lorries are about 4.9 percent while Public Buses and Taxis are about 0.29 percent and 0.41 percent respectively. Hire and drive car and other vehicles such as agriculture and heavy duty vehicles are 0.08 percent and 0.03 percent.

Table 3: Total number of registered vehicles by type

	Tubic 5. Total named c	registered venicles by type	
No	Type of vehicles	Number of vehicles	_
1	motorcycle	771,432	
2	car	831,606	
3	bus	5,073	
4	taxi	7,317	
5	hire & drive car	1,583	
6	lorry	86,722	
7	Others	58,289	
8	total	1.762.022	

Source: Road Transport Department, JabatanPengangkutanJalan,JPJ)Johor Bahru. 2014

Since the majority of the vehicles use fossil fuel, there is an indication of high  $CO_2$  emission from vehicular sector particularly from privately owned Cars and motorcycles. The study also shows that the public transport sector in Johor Bahru is not adequately developed and poorly patronized due to high private vehicle ownership.

#### 4.3 Measuring Carbon Dioxide Emission in Johor Bahru

The assessment and determination of the existing levels of CO<sub>2</sub> is critical to formulate policies for emission reduction, encourage investments in energy efficiency and promote low carbon development in Johor Bahru. Since cities consume 78 percent of the world's energy and produce 60 percent of the total carbon dioxide emission [32], the development of GHG inventory from energy use resources is crucial to present the picture of the current status of carbon emissions as a key to achieving energy action plan. The measurement and monitoring of carbon emissions in Johor Bahru is based on the Asia-Pacific Integrated Model (AIM) or ExSS to provide scientific findings and Quantitative modeling of carbon dioxide emissions Johor Bahru [17]. In order to manage carbon dioxide emission effectively and achieve low carbon development in Johor Bahru, direct measurement of extent of emission and monitoring of levels of reduction from transport and electricity sectors is very essential. This is because transportation accounts for 95 percent of the global oil consumption and about 48 percent of total energy is used in buildings [33]. Furthermore, what cannot be measured cannot be managed and monitoring is only possible once there is agreement on what to measure. This is not to say that attempts have not been made to measure extent of Carbon emission in Malaysia. For instance, there are two commonly used tools for assessment of crabon emission in Malaysia among which are the Extended Snapshot tool (ExSS) and the Low Carbon Cities Framework and Assessment System (LCCF). These tools are briefly discuss below for the purpose of comparism and clarity.

### 5 Low-Carbon Emission Assessment Models 5.1 Asia-Pacific Integrated Model (AIM) Extended Snapshot Tool

The Asian–pacific Integrated Modeling System otherwise known as the Extended Snapshot Tool (ExSS) was developed by Kyoto University and the National Institute for Environmental Studies (NIES), Japan for the creation of low carbon scenarios [34]. This was used to account for GHG emissions upon which the GHG emission mitigation options of Iskandar Malaysia was based. The tool is a static model consisting of simultaneous equations with about 6000 variables that considers a wide variety of variables to build up its assumptions among

These include economic growth and changes in industrial structure; demography; changes of lifestyles in terms of

consumption pattern and energy service demand; transport volume and structure; and low carbon measures that include energy-efficient devices and buildings, renewable energy, modal shift to public transport and fuel mix in power generation [35]. Majority of these multiple data are large and whose validation may be difficult and besides do not have a direct relationship to carbon dioxide emission. For instance, ExSS used the Base-year data for Population and Household; Input Output table (or, regional economic accounting); Transport demand (Passenger & Freight); Building Energy demand and Energy supply, to make reference for future scenario such as population projection, economic projection or planning, transport planning, energy strategy. Therefore, in view of the volume of variables used for modeling and the complexity of its design, it is difficult to interpret the simulation results of Extended Snapshot Tool (ExSS) by the policy makers and are not be easily understood by the administrators.

#### 5.2 Low Carbon Cities Framework and Assessment System

Among the existing carbon calculators used in Malaysia is the Low Carbon Cities Framework and Assessment System (LCCF). The functions of this Assessment are:

- Encourage and promote the concept of low carbon cities and townships in Malaysia.
- To guide cities in making choice/decision towards greener solutions.
- To assist stakeholders to develop action plans for low carbon development.
- As a tool to calculate the carbon emission within the development.

The tool recognized 4 relevant carbon factors as elements contributing to GHG emission, namely:

- Urban environment
- Urban transportation
- Urban infrastructure
- · Buildings

This tool consider many variables such as 13 performance criteria and 35 sub criteria in the assessment of carbon emission. The Malaysian Ministry of Energy, Green Technology and Water (KeTTHA) through cooperation with NEDO (New Energy and Industrial Technology Development Organization), Japan, used the LCCF in Putrajaya and Cuberjaya as a showcase for other townships in Malaysia. Like ExSS, the LCCF was also considered to be rather complicated. Although IRDA assisted to provide data for LCCF, the tool was not used for Johor Bahru in view of the large size of measurable variables required and the lack of understanding of how figures were derived. This may affect making informed decisions towards developing and implementing sound policies and practices towards CO2 emission reduction. In view of the inadequacies of existing tools to measure the actual CO2 emission as well as the poor understanding of the process by administrators, this study adapted a prototype tool designed by the researcher - the Malaysian University Carbon Emission Tool (MUCET) to chart the path for emission reduction in Johor Bahru. MUCET focused towards reduction of CO2 emission from fossil fuel based energy use.

#### 5.3 Malaysian University Carbon Emission Tool (MUCET)

The Malaysian University Carbon Emission Tool (MUCET) was developed by the researcher and also tested in UTM, Malaysia [18,27]. The tool was designed based on the emission factors for Malaysia Peninsula electricity supply as given by

International Energy Agency (IEA) and according to the fuel mix of electricity purchased from Tenaga Nasional Berhad (TNB). MUCET also integrated the emission factor for Gasoline and Diesel combustion in vehicles in accordance with the Code of Federal Regulations at 40 CFR 600.113-78 based on Inter-Governmental Panel on Climate Change (IPCC) guidelines [36]. Figure 7 shows the adapted MUCET for Johor Bahru City Carbon Emission. Column A present the service demand sectors for electricity and transport, while categories of energy use are shown in column B. The annual figures of Petrol/Gasoline and Diesel consumed for traffic movement in Litres of fuel, the electricity measured in kWh and also Natural gas consumption (where applicable) are input into the calculator. The tool uses the conversion formula embedded in each column to generate the carbon emission equivalent. It also automatically converts the total annual electricity input for these sectors in kWhr into tons of carbon dioxide (t CO2).

The tool offers direct measurement of CO<sub>2</sub> emission from combustion of fossil fuel use in Transport and Electricity, which constitutes about 78% of total emission in Cities [33]. It can also measure, monitor and simulate policy outcomes by inserting the values of electricity or fuel consumption for the category of use or service demand in the appropriate columns and rows of types of energy use. Other service demands such as Agriculture and Water that require the combination of fuel and electricity energy use can also be calculated in a similar manner to show total percentages as well as their percentages from the total emission.

# 6 The Development of Emission Tool for Johor Bahru

For the purpose of this study, the Malaysian University Campus Emission Tool (MUCET) was modified for the measurement of carbon emission in the city of Johor Bahru. The tool focused mainly on energy and carbon emission related service sectors arranged into two categories according to generated electricity and transport fuel energy. The associated CO<sub>2</sub> emission was based on the emission factors for purchased electricity supply from Taman NationaBerhad (TNB), according to the fuel mix data and figure offered by the Sustainable Energy Development Authority (SEDA). For the transport sector, the emission factor for gasoline and diesel combustion in vehicles was integrated in the tool in accordance with IPCC guidelines mentioned above.

# 6.1 Description of the Malaysian University Carbon Emission

The Malaysian University Carbon Emission tool adapted for Johor Bahru consists of columns classified into three (3) groups namely; Sources of Carbon Emission, Columns of Measured Parameters, Results and Emission Summary. There are five (5) major groups of rows namely; Rows of Input Variables, Total Carbon Emission percentage, Row of Constants, Rows of Input Variable for Electricity and Rows of Input Variable for transport.

The tool calculates CO<sub>2</sub> emission from the major service areas that constitutes Johor Bahru's energy consumption pattern. These are arranged into two categories of Electricity generation and Transport fuel energy respectively. The sources of carbon emission are essentially the services associated with electricity and fuel energy use.

Α	В	С	D	Е	F	G	Н	l l	J	K	L	М
	Constants	Petrol 2.3	Diesel 2.7		Natural Gas 0.02							
Service Sector	Category	Total No.	Zone	Fuel		Electricity	Natural Gas	Carbon	C/P	C/A	Intra Sector %	% of Sector
Service Sector				Petrol	Disel	KWh		Emission				76 OF SECTOR
	_	Column2	Column3	Column4 💌	Column5 💌	_	Column7 💌			Column10 *	Column11	
	Domestic/Residential					9,876,666.00		7318609.506			56.84%	
	Commercial					4,746,239.47		3516963.45			27.31%	
	Industry					1,648,631.00		1221635.57			9.49%	
lectricity Energy	Street Lighting					1,105,660.00		819294.06			6.36%	
use (KwHr)	Agriculture							0.00			0.00%	
	Water							0.00			0.00%	
	others							0.00			0.00%	
		0.00		0.00	0.00	47 277 405 47	0.00	0.00			0.00%	
	Grand Total (Electricity)	0.00	0.00			17,377,196.47	0.00	12,876,502.58 Carbon			100%	67.77%
	Vehicle Types	Total No.		Annual Fuel ( Petrol	Diesel		Natural Gas	Emission	C/P	C/A	Intra Sector %	
	Column1	Column2	Column3 🔻	Column4	Column5 💌	Column6	Column7	Column8	Column9 💌	Column10 🔻	Column11 💌	
	Cars			2212219				5088103.7			83.08%	
	Van			132538				304837.4			4.98%	
	4-wheel Jeep			67845				156043.5			2.55%	
	Motorcycles			179109				411950.7			6.73%	
Transport Fuel	Bus	1			34523			93212.1			1.52%	
Consumption	Taxi	1		5678				13059.4			0.21%	
(Litres)	Pickup	1						0			0.00%	
	Lorry/ Trailer	1			14184			38296.8			0.63%	
	Others	1		6754	1355			19192.7			0.31%	
	Grand Total (Vehicles)	0.00		2,604,143.00	50,062.00		0.00	6,124,696,30			100.00%	32.23%
	Grand Total (All)	0.00		#REF!	#REF!		#REF!	19,001,198.88			20010070	100.00%

Figure 8: MUCET for City Carbon Emission (Source: Modified after Abdul-Azeez (2012))

These constitute Johor Bahru's energy system and determine the city's operation and performances as listed below:

- Electricity
- Domestic/Residential
- Commercial
- Industry
- Street Lighting
- Others (such as energy use for Agriculture, for production and distribution etc)
- Transport types
- Motor cycles
- Cars
- Buses
- Hire &Drive car
- Lorry/Trailer
- Pick-up
- Other vehicles (may be identified such as mobile machinery, agricultural and construction equipment or other transport modes within the city.

The columns of measured parameters include category of uses, fuel types (Petrol/ Gasoline, Diesel and Natural Gas where applicable) for transport and the annual electricity consumption measured in kWh for all category of uses. Using the imbedded constant values, the calculator automatically converts the total annual inputs of electricity and fuel into tons of carbon dioxide (tCO<sub>2</sub>) displayed under each column. The last section of the columns constitutes the columns of percentages of CO<sub>2</sub> contribution by each element within the sector to the overall total carbon emission. The values can be observed and compared at a glance, upon which informed decisions can be made based on the values and emission targets can be set using the results. The tool

also consists of rows of input variables, which are based on the two (2) service sectors i.e. Electricity and Transport. Similarly, the rows can be increased according to the category of uses and measured parameters. The calculation of emission from fuel consumption of vehicles is based on the total amount of fuel recorded in litres where the conversion rates of the inputs are embedded within the rows of the tool, so that the corresponding value of carbon emission is automatically generated in tons of CO<sub>2</sub> (tCO<sub>2</sub>). However, where the record of fuel purchase is NOT available, the total litres of annual fuel consumption can be calculated as a product of the total annual distance travelled and the fuel efficiency of the vehicle type as given below:

Total fuel Consumption=
$$\frac{\text{total annual distance travelled}}{\text{fuel efficiency of vehicle}}$$

$$\mathbf{TFC} = \frac{\mathbf{T}}{\mathbf{ff}} \tag{1}$$

where, TFC is total annual fuel consumption, T is average distance travelled and ff is fuel efficiency of vehicles. The calculation of total fuel consumption was modified based on the formula adopted for the Greenhouse Gas Emissions Inventory in Hobart and William Smith Colleges (Clayton and Thompson, 2008). The standard emissions factors for gasoline is given as 2.3 kilograms of Carbon dioxide equivalent (kCO<sub>2</sub>) while the standard emissions factors for Diesel oil is given as 2.7 kilograms of Carbon dioxide equivalent (kCO<sub>2</sub>) [36].

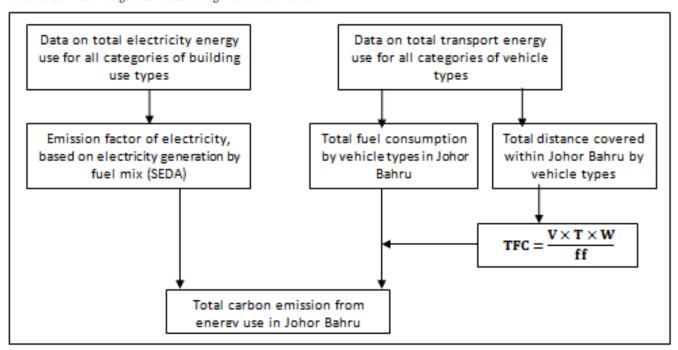


Figure 9: Sources of data for energy use and carbon emission for Johor Bahru( Source: Researcher's field work (2015)

#### 6.2 Major sources of energy use data

The major sources of data for energy use and carbon emission Johor Bahru include data from meter readings of total purchased electricity for all buildings categories and use types as well as data from fuel consumption for the total transport energy use or the total distance covered within Johor Bahru by vehicle types as shown in Figure 9.

The data required for testing the tool was not available from a primary source. The study relies on secondary source of data whose reliability could not be ascertained. Similarly, it was not possible to obtain data on annual fuel consumption for energy use for all categories of vehicles because such records were not kept by vehicle owners. It was also not possible to obtain accurate meter reading for electricity consumption for categories of use in Johor Bahru. For the purpose of this study data from the Load growth scenario for Iskandar Malaysia (Table 1) and the total number of registered vehicles by typereferences (Table 2) were used to test the tool. It was noted that the highest 59 percent of carbon emission comes from the industrial sector while the street lighting emits about only 1percent and residential and commercial sectors have 23 percent and 17 percent respectively (Figure 10). Therefore, emission reduction policy focused on the industrial sector could reduce overall carbon emission in Johor Bahru. The Percentage of Carbon Emission from Transport Sector in Johor Bahru is presented in Figure 10. Cars and Motorcycles produced the highest levels of CO<sub>2</sub> emission of 47 percent and 43 percent respectively, while the Buses, Taxis and Hired & Drive vehicles registered in the city have very negligible amount of emission. This is probably due to high levels of Cars and Motorcycle ownership in the city. Therefore, encouraging policies that target these sectors could achieve significant reduction in level of carbon emission.

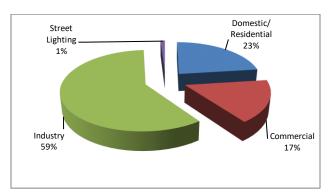


Figure 10: Percentage of CarbonEmission from Electricity Sector in Johor Bahru (Source: Researcher's field work (2015))

MUCET is user-friendly, less complicated and less cumbersome compared to its counterparts. The challenge of data collection especially for transport can be overcome by encouraging transport owners to keep log-books that record vehicular movements throughout the year. Some reduction in vehicle license fees can be arranged as incentives in exchange for submission of such records. Finally, the tool could be improved further such that vehicle owners can send information online as soon as the vehicle is fuelled so as to update the data continuously similar to the online carbon calculator.

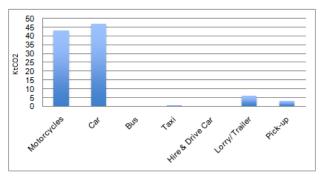


Figure 11: Percentage of Carbon Emission from Transport Sector in Johor Bahru (Source: Researcher's field work (2015))

#### 7 Conclusion

Cities worldwide are taking advantage of urbanization and building on economic growth for wealth generation. Carbon emission will also continue to built-up as long as economic growth and wealth generation in the cities rely on fossil fuel based energy sources. Low carbon development could change the trend, but this will depend on better management of cities' emission particularly from energy use sources that contribute significantly to carbon emission.

Promoting low carbon development through carbon emission reduction measures in Johor Bahru will require a movement towards a mix of low-carbon power generation to achieve its goals. This will involve utilizing renewable energy sources to replace the fossil-fuel based energy in transport and electricity and providing incentives for specific sectorpolicy reforms in urban transport policies.

Unless there is an efficient measuring system and the mobilization of stakeholders through strengthened partnerships towards a low carbon future, effective management could be difficult. What is being measured and why, must be understood by all stakeholders, while additional financing is also required to support low-carbon power generation, via zero-emissions technologies for the electricity sector and the implementation of strategies to eliminate transport CO<sub>2</sub> emission.

Major policy implications to achieve low carbon development in Johor Bahru will be to substitute the fossil fuel components of the electricity generation by introducing Biogas and Biomass energy source which the country has in very large quantities (Palm oil plantation) so as to reduce the emission factor of the electricity supply and carbon emission from the electricity sector.

The high energy-intensive transport sector in Johor Bahru has higher global warming potentials. Focusing on policies that encourage investments in energy efficient transport system and improving the public transport sectors, such as using modern technology to retrofit existing stock of public buses could make the sector attractive. Promoting 'low—interest-loans' that favor the purchase of hybrid cars and other conventional best practice strategies could also favor emission reduction in the city.

Among other strategies to achieve energy efficiency in the transport sector is the 'Clean Fuels and Vehicles' which may involve converting to compressed natural gas (CNG) to reduce CO<sub>2</sub> emissions. Lower energy intensities are experienced in countries with high energy prices [37], therefore, Integrated Urban Road Pricing may equally be promising in Johor Bahru. Similarly, the 'Bus Rapid Transit Systems' is popular and is revolutionizing the bus systems around the world. Promoting the Bus Rapid Transit Systems in Johor Bahru will improve

reliability and convenience of the public bus transport systems, increase capacities and attract high ridership levels and also assist to promote low carbon development in a profitable and efficient manner. Similarly, investment in the pedestrian and bicycle facilities by building more infrastructures dedicated to pedestrians and bicycles will encourage a safer and healthier environment and reduce emission of CO<sub>2</sub> from the transport sector

The use of alternative means of transportation such as walking and cycling for short distances within city centers are cheaper, healthier, and less harmful with zero emissions. in recent times, this is a popular trend among many cities worldwide and it assists to decongest traffic and creates harmony. Johor Bahru municipal authority should embark on intensive public campaign and enlighten stakeholders about such desirable means of movement within the city. Also, it is important to identify areas with high potentials of carbon emission, so as to apply suitable mitigation methods along the corridors.

The political will through effective, appropriate policies are essential to drive change. The ability to change the mind-set of the individual consumers in Johor Bahru to recognize and appreciate the link between consumption pattern and environmental impact is essential to promoting low carbon development in the city. Achieving steady movement into the clean energy future requires measurement and monitoring progress of agreed variables of the energy system to make other energy policies of the government feasible within of each demand sector. A key step to this could be achieved through simple method of carbon inventory as offered by the proposed tool - MIJCET

Finally, in addition to promoting green economy, the government of Johor Bahru should focus on direct reduction of CO<sub>2</sub> emission by using the simple and user-friendly tool (MUCET) to monitor the city's carbon emission and to analyze emission inventories on transport and electricity energy consumption which accounts for greater portion of total CO<sub>2</sub> emission of the city.

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#### **Ethical issue**

Authors are aware of, and comply with, best practice in publication ethics specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests and compliance with policies on research ethics. Authors adhere to publication requirements that submitted work is original and has not been published elsewhere in any language.

#### **Competing interests**

The authors declare that there is no conflict of interest that would prejudice the impartiality of this scientific work.

#### Authors' contribution

All authors of this study have a complete contribution for data collection, data analyses and manuscript writing.

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