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MALAYSIAN MUNICIPAL EMISSIONS GAP STUDY

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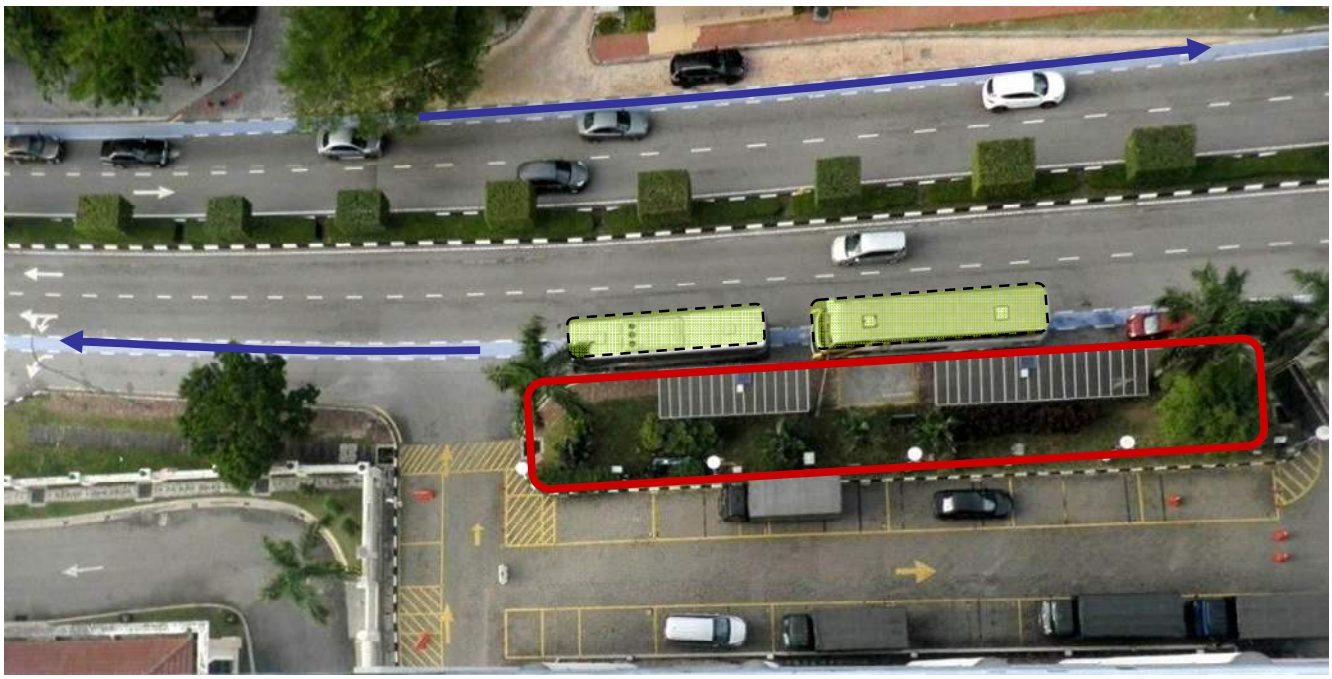
MALAYSIAN MUNICIPAL EMISSIONS:
A CO_2 Emissions Gap Analysis of Selected Malaysian Cities



DISCLAIMER

The findings, interpretations and conclusions expressed in this document are based on information gathered by ARI and its consultants, partners and contributors. Any expressions of opinion or errors are purely those of the author.

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THE PROJECT CONTEXT

The purpose of this study is to promote Green House Gas (GHG) emissions reductions and environmental preparedness and stewardship at the city level as, with increasing urbanization, cities can play a major role in emissions control.

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LIST OF ABBREVIATIONS AND ACRONYMS

AC	Air Conditioning
AMB	Ambitious
ARI	Applied Research International (Policy research division of Focus Applied Technologies)
ASEAN	Association of South East Asian Nations
BAU	Business As Usual
BMW	Bayerische Motoren Werk AG (a luxury German automobile brand)
BOD	Biochemical Oxygen Demand
BREEAM	Building Research Establishment Environmental Assessment Method (UK)
BRT	Bus Rapid Transit
CAIT	Climate Data Explorer from World Resources Institute (WRI)
CARB	California Air Resources Board
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon dioxide equivalent emissions
DECC	Department of Energy and Climate Change (UK)
DOE	Department of Environment
EHCC	Earth Hour City Challenge
EIA	Energy Information Administration (a service of the US government)
EPA	Environmental Protection Agency (of the USA)
EPU	Economy Planning Unit
EQA	Environmental Quality Act
EV	Electric Vehicle
FEE	Foundation for Environmental Education
FTZ	Free Trade Zone
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GHG	Green House Gas
HC	Hydrocarbon
HFCs	Hydrofluorocarbons
ICLEI	International Council for Local Environmental Initiatives-Local Governments for Sustainability
ITS	Intelligent Transportation System
JKR	Jabatan Kerja Raya (MOW)
JB	Johor Bahru
JBIP	Johor Bahru Iskandar Putri
JPJ	Jabatan Pengangkutan Jalan or Road Transport Department
INDC	Intended Nationally Determined Contribution
KATS	Ministry of Water, Land and Natural Resources
KeTTHA	Kementerian Tenaga, Teknologi Hijau dan Air or Ministry of Energy, Green Technology and Water
KL	Kuala Lumpur, also Kuala Lumpur and Klang Valley metropolitan area
KPKT	Ministry of Urban Wellbeing, Housing and Local Government
km	Kilometer
kWh	Kilo Watt hours
KWP	Ministry of the Federal Territories and Urban Well-being
LEED	Leadership in Energy and Environmental Design (US)

LED	Light-emitting diode
LPG	Liquefied Petroleum Gas
LTO	Land Transportation Office (of Singapore)
M	Million
MAGIC	Malaysian Global Innovation & Creativity Centre
MBIP	Majlis Bandaraya Iskandar Putri
MBMB	Majlis Bandaraya Melaka Bersejarah
MBJB	Majlis Bandaraya Johor Bahru
MBPP	Majlis Bandaraya Pulau Pinang
MBSP	Majlis Bandaraya Seberang Perai
MCKIP	Malaysia-China Kuantan Industrial Park
MEA	Ministry of Economic Affairs
MESTECC	Ministry of Energy, Science, Technology, Environment and Climate Change
MGTC	Malaysian Green Technology Corporation
Mt	Million Metric Tones
MOT	Ministry of Transport
MOW	Ministry of Works (JKR)
MPSP	Majlis Perbandaran Seberang Perai (recently changed to MBSP)
MPV	Multi-purpose Vehicle
MRT	Mass Rapid Transit
NDCs	Nationally Determined Contributions
NGO	Non-government Organization
NRE	Ministry of National Resources and Environment
NPP	National Physical Plan
NPPC	National Physical Council
NRE	Ministry of Natural Resources and Environment
PEMANDU	Performance Management and Delivery Unit
PFCs	Perfluorinated compounds
PJ	Petaling Jaya
PKT	Passenger-kilometer traveled
PMD	Prime Minister's Department
POME	Palm Oil Mill Effluents
Puspakom	Pusat Pemeriksaan Kenderaan Berkomputer or Malaysian National Automobile Inspection Center
RM	Ringgit Malaysia
ROI	Return on Investment
RTD	Road Transport Department (JPJ)
SEDA	Sustainable Energy Development Authority Malaysia
SF_6	Sulphur hexafluoride
SIRIM	Standards and Research Institute of Malaysia
SITS	Selangor Intelligent Transportation System
SS2	A district of Petaling Jaya
SUV	Sports Utility Vehicle
SW	Scheduled Waste
SWCorp	Solid Waste Corporation of Malaysia
TNB	Tenaga Nasional Berhad (Electric Power Utility)
VIP	Very Important Person
VKT	Vehicle-kilometer travelled
tCO_2e	Tones Carbon dioxide equivalent emissions

Toe	Ton of Oil Equivalent
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
US/USA	United States of America
USD	United States Dollar
W	Watts
WRI	World Resources Institute

1. EXECUTIVE SUMMARY

The purpose of this study is to identify ways which the national, state and city governments in Malaysia can improve development of environmentally sustainable policy. Specifically, it seeks areas in where there are existing gaps in the planning process of local governments as well as inter-departmental issues. This study primarily consisted of interviews with various city governments and federal bodies, but also included some basic emissions modeling and surveys of individuals in the cities under study. A list of 16 actions are recommended based on the results of this investigation, with the most relevant being summarized below. These are separated into two categories: overarching actions, and individual topic "niche" actions.

OVERARCHING ACTION #1:
Establishment of a "Carbon Assessment Training Team"

Many municipalities do not have all the expertise required to evaluate carbon savings from every project, thus they have a hard time prioritizing projects. Although a wide range of carbon accounting tools exist, what is needed is a dedicated team of experts who are accustomed to assessing city level projects for CO_2 impact and cost. This team should use a standard set of tools and work closely with the various cities, providing training guidance in evaluating the various projects. This team can be drawn from existing resources within various government bodies, such as DOE, MGTC, MESTECC, local universities and Non-Government Organizations (NGOs) and even the cities themselves. Subsequently this core group of experts would work directly with various cities to review and help analyze the current and proposed sustainability actions, while training up the individual city staff on the appropriate tools and techniques.

OVERARCHING ACTION #2:
Establishment of a National Body of City Level Sustainability Practitioners

The "Carbon Assessment Training Team" can also be used as a platform for addressing inter-departmental issues via the establishment of a national level "Association of City Carbon Practitioners". As cities encounter trans-boundary issues or problems related to jurisdiction, this "Association" could then work closely with federal level bodies and concessionaires. The Association would carry much more weight than an individual city administration worker, and could get the appropriate contacts within the other government departments, facilitating information exchange (eg. getting local level electricity usage from TNB), and affecting change. This would allow cities to exert much greater influence over issues involving extra-city bodies (such SW Corp and dump site methane sequestration), and many of the other trans-boundary issues highlighted in the study. Finally, this body can aid the cities in finding appropriate funding sources for their emissions abatement programs both from within the government as well as from outside sources.

OVERARCHING ACTION #3:
Development of Simple Guidelines for CO_2 Emissions, Energy Efficiency and Sustainability

For many CO_2 reduction projects a tool or national level standard may exist, but is too complex to be readily interpreted for either project implementers or auditors. What is needed is a simple set of guidelines stating in clear language how a project should be evaluated and what is considered an acceptable design in terms of energy efficiency and sustainability. This will be one of the main responsibilities of the aforementioned national "Carbon Assessment Training Team", as well as one of the major tools to be shared with the municipalities. These guidelines should conform to, and perhaps help form, national level standards and policy in much the same way the California Air Resources Board (CARB) develops state level emissions standards for California in the USA which are generally adopted by the national Environmental Protection Agency (EPA) after some time. The guidelines will have to cover a wide range of different areas including:

- New Building Energy Efficiency Standards
- Existing Building Energy Efficiency Retrofitting
- Solid Waste Separation, Recycling and Composting
- Industrial Efficiency Guidelines
- Urban Green Space Guidelines
- River Cleanup and Contamination Prevention

This will greatly simplify the task of the participants in developing efficient low carbon cities with reasonable expectations of carbon reductions and project costing.

NICHE TOPIC ACTIONS

River Cleanup and Contamination Reduction

A good deal of river contamination is related with the public's attitude. Tossing garbage at the side of the road or in a *longkang* is a personal habit, not directly within the control of the city administration. Here, behavior modification is required. Generally, this is a slow process, requiring intervention at the schooling level, and public awareness campaigns. As this is a country-wide problem, and can strongly effect the aquatic wild life, this presents a unique opportunity for public education to have a large impact by uniting the cities' efforts on a nationwide basis. Additionally, working together with cities and the Department of Environment, can also help improve river water quality by emphasizing the impact of eutrophication, and aiding cities in tracing water quality problems back to their source.

Solid Waste Separation and Recycling

Often cities delegate recycling to third parties[1]. Generally, these "concessionaires" or contractors are primarily interested in recycling profitable materials such as aluminum, paper and steel. Many recyclable materials are often overlooked or become a problem for the cities. Additionally, studies show that almost half of the solid waste in Malaysia is organic material that could easily be "recycled" in the form of compost, reducing the burden on the land fill, reducing CO_2 emissions,

[1] From city feedback (Penang, August 2019) and interview with SW Corp January 2020

and generating useful fertilizer. Currently there are great differences in recycling practices and effectiveness between the various cities. An NGO could take on a major role in helping coordinate and standardize efforts in materials separation and recycling, especially including composting. This would involve educating city administrators as to the best practices, and coordinating efforts between the cities, contractors and SW Corp.

Building Retrofit Standards and Public Education

New building standards are crucial to the long-term sustainability of cities, however the “legacy” existing structures remain largely unaffected by progress in new building efficiency. One of the challenges here is to educate the owners of existing structures to the benefits (in terms of comfort, savings and CO_2 reduction) of existing building efficiency upgrading. Consumers need very straight-forward guidelines and ways to quickly evaluate the cost/benefit or return on investment (ROI) of various building improvement options. A suitable environmental NGO could help this via public awareness campaigns, development of standard tools and calculations based on real-world applications of efficiency upgrades, and perhaps helping form a nationwide data base of implemented projects along with their cost and energy-savings.

Urban Green Space Promotion

A final vital, but often overlooked area is that of urban green spaces. These enclaves enhance the quality of life, and can have a significant impact on CO_2 reduction. Because of the difficulty in calculating the exact CO_2 impact, however, they may be overlooked in some urban emissions reduction plans with development steadily encroaching upon existing urban green spaces. An environmentally conscious NGO could help highlight the benefits of urban green spaces by providing training on exactly how green spaces impact emissions, provide examples of various case studies, and promoting individual green space projects. This would include both public education programs as well as directly working with the city administrators and national emissions control teams.

2. INTRODUCTION

The "Paris Agreement" developed in 2015 during the 21st Conference of Parties (COP21), which entered into force on 4th November 2016 aims at reducing carbon emissions by 2030. As a legally binding document, the Paris Agreement sets out a global action plan to put the world on track to mitigate the effects of climate change by limiting global warming to below 2°C. Among others, the agreement identified the following crucial areas as essential to achieve its goals:

- Mitigation – reducing emissions fast enough to achieve the temperature goal.
- A transparent system and global stock-take – accounting for climate action.
- Adaptation – strengthening ability of countries to deal with climate impacts.
- Loss and damage – strengthening ability to recover from climate impacts.
- Support – including finance, for nations to build clean, resilient futures. Countries need to work to define a clear roadmap on ratcheting up climate finance to USD 100 billion by 2020.
- Global response - to the threat of climate change through intended nationally determined contributions (INDCs).

For Malaysia's INDC, the country intends to reduce its GHG emissions intensity (per unit of GDP) by 45% by 2030 relative to the emissions intensity in 2005. Thus, the goal of this study is to evaluate the efforts made by Malaysian cities.

2.1 Objectives

The objectives of this project are:

To carry out a review of efforts taken by our stakeholders related to sustainable cities:

- Analyze current strategies being implemented at federal and state level to promote green or sustainable cities in fulfillment of the INDCs of the Paris Agreement
- Study existing legislation at each state and federal level to identify the extent of how sustainability may be incorporated, as well as identifying the lack of legislature and policy that affect strategy implementation, based on the following subject matters:

  a) Waste, water and energy management
  b) Cleaner air
  c) Community engagement
  d) Renewable energy efficiency and energy efficiency
  e) Sustainable Buildings
  f) Sustainable Public Transport & City Eco-mobility
  g) Other relevant aspects that contribute to green city status

To analyze and develop the study results into presentation format.

To convert the findings and recommendations into a palatable and interesting power point presentation format. The final version of the presentation is to be presented to the stake holders.

2.2 Methodology

The study includes the following activities:

i. Stakeholder interviews which involves at least 10 cities (key staff including senior management

team members) and relevant stakeholders involving field data collections among the list below. The interview will involve a series of guided questions that will be used to gauge the council's interest in the following issues:

- Sustainable green actions that are being undertaken
- Interest in working with external partners especially

ii. Examine the council's green efforts against the Ministry of Energy, Science, Technology, and Climate Change's Low Carbon City Framework and other national or international definitions of green city agendas.

Visits for data collection from councils included following city councils:

- Penang Island City Council
- Seberang Perai City Council
- Shah Alam City Council
- Historic Melaka City Council
- Sepang Muncipal Council
- Petaling Jaya City Council
- Johor Bahru City Council
- Johor Bahru Tengah City Council
- Langkawi Municipal Council
- Ipoh City Council

The following stakeholders were identified as potential sources of data as well:

- Ministry of Energy, Science, Technology & Environment Climate Change (MESTECC)
- Ministry of Water, Land and Natural Resources (KATS)
- Ministry of Housing & Local Government (KPKT)
- Ministry of Federal Territories (KWP)
- Ministry of Transport (MOT, JPJ)
- Town and Country Planning Department (Plan Malaysia)
- Malaysian Green Technology Corporation (MGTC)
- Malaysian Department of Environment (DOE)
- Department of Statistics Malaysia (DOSM)
- Jabatan Pengurusan Sisa Pepejal Negara (JPSPN)
- Solid Waste Corporation of Malaysia (SWCorp)
- National Water Services Commission (SPAN)
- Indah Water Konsortium (IKW) Sdn Bhd the national sewerage company
- Jabatan Kerja Raya Malaysia JKR
- Agensi Pengangkutan Awam Darat (APAD)
- Tenaga Nasional Berhad (TNB)
- Energy Commissions (ST)

The data collection is based on a questionnaire (available in Appendix 1) which draws out problems faced by the city in compliance with the green city agenda. After the data analysis the findings will be presented to the cities with the hope that they will have an easier time making changes that reduce emissions.

2.3 Output

This project was evaluated at several stages throughout the duration of the project, including an

Inception report early on, and several progress reports during the data collection and stake holder interviews showing the current data and analysis. These were accompanied with meetings and presentations to share current findings and discuss results and any issues arising during the study. In September 2019 a final report was generated containing all the findings and recommendations. This was reviewed by by ARI and modified as required. The ultimate report was also be published as an ARI technical report for internal and external usage.

3. PROGRESSION OF WORK

The major objectives of this study were to carry out an analysis of the efforts taken by our stakeholders to reduce overall GHG emissions from the various municipalities. To asses this, we were primarily dependent on information provided by the city councils in coordination with some on-site verification performed separately. We started the process by identifying the various stakeholders, and getting their buy in to the overall study. Data from federal agencies was collected first, mostly from on-line sources, giving us a good overview of emissions and environmental sustainability at the federal level before approaching the individual cities. Next, meetings were held with the various municipality governments, reviewing their data, and performing some on-site evaluations.

The first step in this work was taken on 7-03-2019 in a meeting at Malaysia Green Tech Corp (MGTC) at their headquarters. This was held in conjunction with the low carbon transport committee meeting taking place at the time. The following organizations were present during this meeting:

- Deutsche Gesellschaft für Internationale Zusammenarbeit, (German Society for International Cooperation, GIZ)
- University Technology Malaysia (UTM) and University Malaya (UM)
- Plan Malaysia
- Malaysian Automotive Institute (MARII)
- United Nations Industrial Development Organization (UNIDO)
- Malaysian Green Technology Corporation (MGTC)
- Malaysian Department of Environment (DOE)
- Department of Statistics Malaysia (DOSM)

Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) was invited, but did not attend.

One of the primary goals of this meeting was to determine which organizations would be responsible for supplying the various data. This was determined in a group discussion, with input from all parties present. It was decided by consensus that the following organizations should be responsible for the listed data at the federal level:

ORGANIZATION	DATA - ROLE
MESTECC	Overall focal organization for the study
Dept. of Environment	Air and Surface Water Quality, Industrial Effluents
JPSPN/SW Corp./PPT	Solid Waste, Recycling volumes
DOSM	Industrial activity (processes and volumes)
SPAN	Fresh water usage
Indah Water/IWK	Waste water volumes and levels of cleanliness
JPJ/JKR	Vehicular Traffic volumes
JPJ/JKR/MOT	Freight traffic volumes
APAD	Public transportation modes, distances, costs and stops
TNB/ST	Electrical Power Consumption
DOSM	Population, working population
DOSM	Municipality area, industrial areas, area of parks
DOSM	Industrial activity (processes and volumes)

Additionally, the initial questionnaire was reviewed for completeness, and some modifications were made based on feedback from the agencies present.

Of special note was the introduction of this work to Saiful Adib Bin Abdul Munaff of MGTC who is heading the “Low Carbon Cities” project. They have developed a city scale carbon emissions tool LCCFTrack, and have already collected data from some of the cities on our list.

The next step was to schedule a meeting with MESTECC, to get their buy in as the lead, or focal organization at the federal level. This meeting was held on 4th April 2019 with Jaya Singham Rajoo presiding. At that time Mr. Rajoo stated that he was not interested in having MESTECC lead, or be the focal organization for this study, but instead suggested that the Ministry of Housing and Local Government (KPKT) might be more appropriate, as they are focused more directly on cities. We contacted KPKT on multiple occasions to set up a meeting with KPKT in order to host the initial stake holder workshop. Due to the difficulties in scheduling this second federal level stakeholders workshop never took place, and work directly with the cities proceeded.

In parallel with this we contacted each of the municipalities and identified the appropriate liaison person in each city for the data required. Resistance on the part of some federal organizations to take part in this study was strongly contrasted with the enthusiasm with which it was embraced by many of the municipalities. The first Interim Report was issued at this time detailing the data collected, and initial feedback from the various stakeholders.

The initial plan was to approach the individual municipalities only after the existing federal level data had been collected and reviewed. However, in light of the delays in getting a designated lead organization at the federal level, we started meetings with the municipalities to get their buy in, and begin data collection. Meetings were held with MBPP on 11th April with a follow up meeting on 23rd April, and the municipal government of Seberang Perai on 12th April 2019. Both municipalities (during the course of this study Seberang Perai was officially converted into a “city”) were enthusiastic about their participation in this study, thus much useful information was gathered. We later held a meeting with MESTECC Eko-Inovasi in May. Petaling Jaya was interviewed on 6th August, with Johor Bahru and Johor Iskandar the following day, and Ipoh on 8th August. Sepang town counsel was interviewed on the 28th, Melaka on the 29th and Shah Alam on the 30th of August. Finally Langkawi was interviewed on 12th September 2019. In addition, a follow up meeting was held with Mohd. Zamzuri Hussain, chief Assistant Health Officer of the Penang Island City Counsel to discuss the solid waste disposal in Penang in greater depths. SW Corp. finally granted us an interview in January 2020.

During visits to the cities we also performed on-site data taking in the form of traffic and vehicle surveys, household surveys and observations to determine the reliability of the given data, as well as filling in any missing data with the best estimate possible from first hand observation.

Data was analyzed, and compared to federal level data, as well as other cities to determine which actions might have the largest impact on emissions. A report detailing the findings was prepared in September 2019 to the various contributing organizations for comment. A final version of the report was provided to ARI in October 2019, with final edits incorporating their feedback in March 2020.

Finally, in parallel with the above on-going work, we were able to contact the “City Nudge Accelerator” a new initiative to offer “nudges” to cities in developing countries on a risk-free basis, to have an

impact in the domains of water consumption, electricity usage, and tax collection (Ideas24). We had a teleconference with Ideas42 on 15th March, 2019. They expressed interest in this study, and are looking forward to the final report, as well as being introduced to any of the cities seeking to improve their emissions and long term sustainability.

Over the course of this study we met with and interviewed the following municipalities:

1. Penang Island
2. Seberang Perai
3. Petaling Jaya
4. Johor Bahru
5. Iskandar Puteri
6. Ipoh
7. Shah Alam
8. Melaka
9. Sepang
10. Langkawi

For comparison purposes a number of relevant city statistics are presented below in Figure 1.

City	Population	Area km²	GHG Emissions $MtCO_2e$/year	2018 OPCC Participant	Low Carbon Plan[2]
Ipoh	657892	643	7.24	No	Yes
Iskandar Putra	592352	367	6.52	No	Yes
Johor Baru	497067	220	5.47	No	Yes
Langkawi	85588	478	0.94	No	Yes
Melaka	484885	277	5.33	Yes	Yes
Petaling Jaya	714175	97.2	7.86	Yes	Yes
Penang	752800	293	8.28	Yes	Yes
Sepang	213470	198	2.35	No	Yes
Shah Alam	740750	290	8.15	Yes	Yes
Seberang Perai	910200	738	10.01	No	Yes

Figure 1. Basic Statistics for the Studied Cities.[3]

This provided a wide range of urban environments, from mature built-up urban areas such as Shah Alam, to the relatively sparsely populated island of Langkawi, and even the major international border town of Johor Bahru. We can see that all of the cities are aware of the importance of climate change and have some carbon reduction plan in progress.

2 While all of the cities report having some kind of low carbon plan, not all are published. Details are founding Appendix 4

3 Populations are from the latest available numbers extrapolated to 2019 at a 1.4% annual growth rate. Emissions are a population based on 11 tones CO_2/person per year.

4. GREEN HOUSE GAS EMISSIONS

Most of the readily available data on GHG emissions are from national level analysis. Often these results are presented in easy to analyze categories, which may be difficult to relate back to individual behaviors and decisions at the city or household level. For example, the BUR presents very coarse categories (Figure 2) including Energy (including both transportation and electrical power production), Industrial Processes and Product Use, Agriculture, Land Use and Waste (both solid and liquid).

Sector	Emissions/ Removals (Gg CO_2eq)				
	1994	2000	2005	2011	2014
Energy	92,049.66	143,141.29	198,514.01	225,060.62	253,517.24
Industrial Processes and Product Use	5,678.85	11,531.89	15,101.60	17,058.02	20,257.83
Agriculture	7,867.26	8,547.20	10,027.98	9,688.04	10,850.77
LULUCF (Emissions)	137,523.00	54,298.83	35,985.19	3,560.42	3,317.15
LULUCF (Removals)	-211,843.11	-235,244.29	-233,918.04	-242,586.19	-267,147.77
Waste	12,603.47	16,670.31	21,927.44	26,958.80	28,217.35
Other (Cross Sectoral Indirect N_2O)	566.53	854.04	1,112.01	1,208.90	1,466.48
Total Emissions	**256,288.77**	**235,047.55**	**282,668.23**	**283,534.80**	**317,626.83**

Figure 2 Green House Gas Emissions for 1994, 2000, 3005, 2011 and 2014 (BUR 2017)

Even when the energy consumption is broken down further, as in Figure 3, Transport is still lumped into a single category including personal cars and motorcycles, public transportation, taxis, freight, and even air and sea travel. These numbers are relatively easy to determine as they are generally related to national levels of consumption of the various fuels (eg. petroleum and diesel dominate the transport category while *Industrial*, *Residential* and *Commercial* categories are dominated by electrical power consumption, derived primarily from coal, natural gas and oil).

For our analysis we need to break out emissions into more specific categories, including city, household and individual levels of emissions. At this level, individual decisions and the effects of policies can be better analyzed. Although our focus will be on households and cities, we still need to ensure that these "local" emissions can be summed up to reflect the national level emissions.

It is worth stating at this point that we are not seeking to establish an extremely precise evaluation of the emissions from each category or activity, rather we are aiming to provide an order of magnitude assessment in order to prioritize the potential mitigation efforts.

Sectors / Year	Transport	Industrial	Residential & Commercial	Agriculture	Non-Energy	Total
1990	5,386	5,300	1,622	-	838	**13,146**
1995	7,827	8,060	2,837	446	1,994	**21,164**
2000	12,071	11,406	3,868	104	2,250	**29,699**
2005	15,384	15,492	5,134	101	2,173	**38,284**
2010	16,828	12,928	6,951	1,074	3,696	**41,477**
2011	17,070	12,100	6,993	916	6,377	**43,456**
2012	19,757	13,919	7,065	1,053	7,497	**49,291**
2013	22,357	13,496	7,403	1,051	7,277	**51,584**
2014	24,327	13,162	7,459	1,045	6,217	**52,210**
2015	23,435	13,989	7,560	895	5,928	**51,806**

Figure 3 Final Energy Consumption by sector (ktoe) (BUR 2017)

In order to evaluate the potential emissions impacts of various city wide policies, it is necessary to have a good idea of the relative green house gas emissions of different aspects of the city, however most published data (Figure 3) is "top down" and must be further broken down in order to relate it back to various urban processes. Many sources of CO_2 are obvious, such as the combustion of fossil fuels in cars, trucks and buses, while others, such as the impact of sewage effluent, is less apparent but still quite important to consider. Finally, other factors, such as the carbon sequestration of urban parks, actually offset some of the emissions created by city dwellers. To fairly balance potential actions, we need to use a common metric, which for green house gas emissions is mass of carbon dioxide equivalent emissions (CO_2e).

The various urban processes emit different amounts of gasses with distinct green house warming potential, therefore these gaseous emissions need to be converted to CO_2 equivalent emissions. Various values are used by different researchers, and some times these values are updated over time to reflect new understanding about the role of the individual gasses in the green house effect. For the purposes of this work we are using the following CO_2 equivalency factors (Figure 4) unless otherwise stated. From the factors it can be seen that methane has a much bigger impact than carbon dioxide.

Gas	Formula	Global Warming Potential CO_2e
Carbon Dioxide	CO_2	1
Methane	CH_4	25
Nitrous Oxide	N_2O	300
Sulfur Hexafloride	SF_6	23,000
Carbon Tetraflouride	CF_4	6,500
Hexaflouroethane	C_2F_6	11,000

Figure 4 Individual gas Global Warming Potential for several common pollutants

As the individual household is the most fundamental unit within a city, it will be instructive to begin our analysis of city level emissions at the household level.

4.1 ENVIRONMENTAL POLICY REVIEW

While a few pieces of environmentally related legislation existed before 1974, notably the Land Conservation Act 1960 and the Protection of Wildlife Act 1972, the main environmental laws of Malaysia were laid down in 1974 in the Environmental Quality Act (EQA) of that year (Sharom 2008). The Department of the Environment, set up the following year, is the primary department in charge of environmental enforcement. Prior to the EQA the government had separate pieces of legislation relating to certain environmental aspects of forests, agriculture, mining and waterways, however these were not primarily environmental protection regulations, and implementation was distributed over a number of disparate governmental agencies (Japan 2020). The EQA has been amended several times since its inception, with ever expanding areas of regulation.

The Department of Environment (DOE) has its headquarters in Putra Jaya and 15 state and 46 branch offices located around the country. In addition the DOE runs the Environment Institute of Malaysia housed in the Universiti Kebangsaan Malaysia in Bangi. The DOE is responsible for monitoring of air and water quality and solid waste effluents.

WATER QUALITY

There are different standards for water depending on the type of water (rivers, ground water, and marine water). The DOE monitors river water quality via a large number manual stations, 1353 stations in 2018, and automated stations, 30 stations in 2018 (DOE 2019). The emphasis is on maintaining safe drinking water, as well as waterways which are safe for other varieties of flora and fauna.

AIR QUALITY

Air quality is continuously monitored by 65 (as of 2017) automated stations monitoring ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), Sulphur dioxide (SO_2) and particulate matter of less than 10 microns in size (PM_{10}) located in a variety of environments, mostly in cities. There are also a few manual air quality stations monitoring particulate matter and heavy metals (DOE 2018). While some of these stations are in industrial zones, results are difficult to correlate to individual factory emissions, thus the DOE is forced to rely on quarterly data from individual factories, and infrequent site checks for quantification of industrial emissions (Japan 2020).

SOLID WASTE

Solid waste is comprised of Domestic Waste, Construction Waste and Scheduled Waste (SW) which is also tracked by the DOE. Domestic waste, apart from electronic waste or hazardous chemicals, is handled by the Ministry of Housing and Local Government, generally through a concessionary such as SW Corp. Construction waste and industrial or Scheduled Waste (SW), are handled separately, with the main focus on waste from industrial processes and power plants. Dross/slag/clinker/ash, gypsum, heavy metal sludges, spent lubricating oil and spent acids made up about 81% of the total scheduled waste in 2017 (DOE 2017).

LOCAL GOVERNMENTS

While environmental policy is largely controlled at the federal level, several aspects pertaining to the enforcement occur at the state or local level, for example local authorities have authority for final approval of building projects which may have to satisfy various federal environmental laws. Things such as land use planning, earth works, agriculture and water are governed at a local level, but have obvious environmental impacts, while drainage and irrigation are “concurrent” being shared by both the state and federal powers (Saleem 2005). This inevitably leads to duplication of effort, and even conflict between local and federal interests. Local authorities are closer to many of the sources of environmental problems, but do not have the resources or knowledge of the experts at the federal level to properly enforce the federal regulations (June 2019).

NATIONAL ENVIRONMENTAL POLICY

The National Policy on the Environment was established in 2002 to help foster continuous economic, social and cultural progress and enhancement of the quality of life of Malaysians through environmentally sound and sustainable development. The objectives of this policy are:

- A clean environment, safe, healthy and productive environment for present and future generations
- Conservation of country’s unique and diverse cultural and natural heritage with effective participation by all sectors of society
- Sustainable lifestyles and patterns of consumption and production

There are eight principles in the National Environmental policy to harmonize economic development goals with environmental imperatives:

1. Stewardship of the Environment
2. Conservation of Nature’s Vitality and Diversity
3. Continuous Improvement in the Quality of the Environment
4. Sustainable Use of Natural Resources
5. Integrated Decision-Making
6. Role of the Private Sector
7. Commitment and Accountability
8. Active Participation in the International Community

The intention is to integrate environmental considerations into development activities and in related decision-making processes, to foster long-term economic growth and human development, and to protect and enhance the environment. It complements and enhances the environmental dimensions of other national policies, such as those on forestry and industry, and takes into consideration international conventions on global concerns. In developing the various policies and standards the DOE is advised by the Environmental Quality Council, a body made up of directors of environment related ministries such as the ministries of Agriculture and Transport, as well as industrial representatives, academics, and nature conservation groups. A list of environmental related rules, regulations and orders can be found in Appendix 5.

While the Environmental Quality Act, and the National Environmental Policy appear to be a good basis for environmental stewardship, and are relatively progressive compared to many other developing countries, they embody several fundamental weaknesses which diminish their

effectiveness at protecting the environment. One of the major criticisms of this policy is the fact that the National Environmental Policy's primary concern is economic development rather than environmental protection (Sharom 2008).

Other criticisms include (Meen-Chee 2006, Mohammad 2011, Samsudin 2013, Sharom 2008):

- Lack of enforcement of the given policies
- Lack of training for policy makers, planners and environmental policy enforcers
- Fragmentation of authority between various local/national bodies
- Lack of data, monitoring and continuous assessment
- Lack of a holistic approach
- Procedural and structural weakness (loopholes) in implementation of policies

Because of the above, Malaysia suffers from inadequate and poorly functioning environmental services (Samsudin 2013). A frequently highlighted weakness of the current system is the often poorly defined division of responsibilities between federal and local governments. Much of the enforcement of environmental regulations is performed at local levels where expertise and equipment may be lacking, while the DOE, which may have the proper tools, is less aware of the situation on the ground at the local levels (Saleem 2005). Apart from the governmental policies, one factor often reducing the effectiveness of policies is the public's understanding and attitude which often hampers the implementation of sound policies (Meen-Chee 2006). This was also noted by the city administrations during the interviews.

On the other hand, the National Green Technology policy (2009) has been singled out as having a great potential to improve Malaysian CO_2 emissions in the face of continuing development, due to its comprehensive measurement of economic, energy, environmental and social factors of "green technology" (Bekhet 2016). Similarly, the National Renewable Energy Policy (2010) should help improve overall emissions by incentivizing the use of renewable energies in upgrading of existing buildings (Che Pa 2017).

Some of the potential solutions to these problems mentioned by the various researchers include the need for greater transparency in governance, better training and resources for policy makers and environmental enforcers, greater integration of authority and cooperative work between federal and local authorities, perhaps even developing a dedicated Ministry of the Environment.

4.2 HOUSEHOLD BASED EMISSIONS STUDY

The easiest city unit to relate to is the individual household. We are defining this as the dwelling of a single family, be that a landed house, row-house or shop lot, or flat or apartment building. From our surveys (complete data can be found in Appendix 6) the individual landed house was the most common type of dwelling (63%) among the survey respondents in the cities where interviews were conducted. The basic carbon footprint of a family dwelling consists of the following aspects, each of which we will examine in greater detail:

1) Emissions encased in the physical building
2) Electric Power consumption
3) Transportation of individual household members

4) Solid Waste disposal and out gassing
5) Sewage out gassing
6) Cooking Gas (in markets not using electricity for cooking)
7) Other Commodities consumption

There are two distinct aspects of a household which effect the carbon foot print. First, there are the materials and construction of the house and products therein which requires energy in the form of machinery and materials to produce. For example, cement is generally taken to have a CO_2 emissions of 900 to 1000 kg of CO_2 emitted for the production of every ton of cement, or about 400kg CO_2 per cubic meter of concrete (Nisbet 2002, Ellis 2019). The second aspect of the building is its energy efficiency. In cold climates this is related with how well the dwelling retains heat and admits light. In tropical areas a building's energy efficiency is related with how well it provides light and air circulation, while reducing heat ingress. Thermally inefficient houses in tropical areas require extensive use of fans, or air conditioning to remain comfortable, directly impacting the household energy consumption, and thus emissions. From our surveys it was noted that the usage of air-conditioning in Malaysia is wide spread, and the largest contribution to residential electricity consumption.

While the building materials in a house may be a significant contributor to GHG emissions, the large number of materials used, and the usefulness lifetime of the house is difficult to assign with certainty, therefore we will focus on a simplified analysis of the more directly tangible factors.

4.3 ELECTRICITY

One of the largest components of emissions comes from a household's electrical power consumption. Electricity is now considered a necessity, and Malaysia has one of the lowest residential electricity tariffs in South East Asia (Yokota 2017). Electrical power is consumed for a wide range of applications. Common household electrical devices are shown in Figure 5.

ELECTRICAL APPLYANCE	POWER (W)	UNITS	HOURS per DAY
Air conditioning	500	2	12
Electric Water Kettles	2000	1	0.5
Electric stoves and Ovens	2000	1	1
Cooking appliances (Blender, Mixer)	250	1	0.5
Fans	75	3	10
Refrigerators	80	1	24
Lighting	20	6	8
TV	50	1	6
Stereo/Radio	50	1	8
Computers	100	1	6
Water pump (rural homes)	100	1	2

TOTAL kWh per day	21.8	kWh
Days / month	30	
Total per month	652.65	kWh
Electrical Tariff	0.34	RM/kWh
Monthly Electricity Bill	221.90	RM

Figure 5 Common electrical devices, power ratings and daily usages

With each appliance, there is a typical power and number of units per house with average usage in hours per day. Summing the power times the number of units and hours per day, we get a typical monthly usage of 653kWh per month, which at the rural electric rate of 0.34RM/kWh would be a monthly bill of 222 RM[4]. While there will be a wide range in electrical power consumption from house to house based on individual preferences and circumstances (we measured a spread of 5 to 200 RM/pax/month in our surveys), clearly one of the largest contributors will be from air conditioning units in houses where they are present. This, in turn, will be greatly affected by the thermal efficiency of the building.

4.4 COOKING GAS CONSUMPTION

In Malaysia cooking is primarily done using bottled Liquid Petroleum Gas (LPG) locally known as cooking gas. Local LPG is predominantly butane (C_4H_{10}) with up to 25% propane (C_3H_8) and smaller amounts of other hydrocarbons. This is typically supplied in either 12 or 14 kg tanks, and used on one or two burner stoves with a heating capacity of about 3 to 5 kW per burner. When LPG is burned in these stoves it generally burns 99.5% completely (EPA 2008), resulting in CO_2 (molecular weight 44) and water vapor. Combustion of butane (molecular weight 58) results in four CO_2 molecules (total CO_2 weight of 176) per butane, and combustion of propane (molecular weight of 44) results in three CO_2 molecules (total CO_2 weight of 132). Taking LPG to be 75% butane and 25% propane and assuming complete combustion we get the following mass of CO_2 per mass of LPG:

$$\textbf{Mass } CO_2 = (0.25 \times 132 / 44 + 0.75 \times 176 / 58) \times \textbf{Mass of LPG}$$

or:

$$\textbf{Mass of } CO_2 = 3.026 \times \textbf{Mass of LPG}$$

Thus combustion of one 12kg LPG tank results in 36.3 kilos of CO_2. To determine the household emissions of CO_2 from cooking gas (excluding the extraction, processing and transportation of the gas and tank) we can use the above equation if we know how long a 12kg tank lasts in that household.

4.5 TRANSPORTATION

In most households the major transportation needs are to get back and forth to work, school, and provisioning of the house, as well as entertainment. Even more so than electrical power, transportation GHG footprint depends on the circumstances and preferences of the individuals involved. Many city specific factors strongly influence a household's transportation emissions. This includes the overall layout of the city, how far it is to work or school, whether public transit options exist and etc. Consumer choice also plays a major role. Consumers are constantly evaluating the following questions:

[4] Monthly kWh = Σ(Power (W) x Units x Hours/Day x 30 days/month x 1kW/1000W)

- Would I prefer to live near where I work, or commute?
- Should I send my kids to the local school, or a better one across town?
- Should I drive an SUV, car, motorcycle or take public transit?

Cars typically consume around four times more fuel per kilometer than motorcycles do, thus motorcycles are overwhelming the choice of lower wage earners based on economics. As salaries rise, people often make choices based not solely on economics, but rather convenience, luxury and life style. This strongly influences their transportation footprint in not only the vehicle they drive, but also where they live and how far away they send their kids to school. Additionally, a lot of transportation expenditures are elective in nature: transportation features strongly in free time activity, such as going to the beach, visiting relatives and etc.

4.6 OTHER COMMODITY CONSUMPTION

Life in modern society requires a certain level of commodity consumption. We are expected to wear a relatively consistent outfit of clothing including shoes, and attain a minimum level of personal hygiene. One of the largest categories of consumption, however, is food. There is a large GHG footprint associated with the food we consume, including petroleum derived fertilizers, agricultural equipment emissions, food processing and transportation, packaging, and retail outlet emissions. Even after consumption, we must still discard the inedible parts (plastic packaging, waste materials, and etc.) which continue to contribute GHG emissions down stream.

4.7 SOLID WASTE

Solid waste is the garbage generated by residences, as well as commercial and industrial operations. A large part of residential garbage is organic material, eg. food scraps, garden waste, paper (Pemandu 2015). As this organic material decays it releases various gasses, mostly carbon dioxide and methane. In Malaysia, most of the garbage from urban residences is taken outside of the city, and placed in a landfill, with varying degrees of drainage, sealing and gas collection.

Malaysian landfills are classified into 4 "levels" based on how they are covered, and how they sequester liquids leaching from the site. A few landfills started sequestering methane starting back in the late 2000's (Abushammala 2011), but it is not yet universally applied[5].

- Level 1 Controlled tipping
- Level 2 Sanitary landfill with a bund (embankment) and daily soil covering
- Level 3 Sanitary landfill with a leachate recirculation system
- Level 4 Sanitary landfill with a leachate treatment system

Saeed determined that Malaysians produce about 1.5 kg of garbage per person per day. Thus, for a national population of 33 million, we would be producing about 18M tons of waste per year (Saeed 2009).

Barton determined that disposing of trash in a landfill which does not collect the effluent gas may contribute 1.2 tones of CO_2 equivalent per ton of trash (Barton et. al 2008). Applying this factor to our 18M tones of waste, we get 21.7M tones of CO_2 equivalent from residential waste burial. Estimates for the fraction of landfill waste coming from residences ranges from 33% to 65% (Samsudin 2013 and Budiharta 2012). Taking an average estimate of 50% of all land fill waste attributable to households, we then get a total solid waste emissions of twice the residential figure of 21.7M tCO_2e, for a total national GHG emissions of 43.3M tCO_2e per year[6]. This agrees well with the extrapolation to 2020 based on the WRI data, which yields 42.9M tCO_2e (CAIT 2017).

4.8 WATER USAGE

Emissions relating to fresh water supply are associated with the construction of catchment areas, forest displacement by reservoirs, pipeline construction, as well as the ongoing electrical power requirements, and emissions from daily operation. As Malaysia is a tropical country with abundant water resources, the emissions from the use of fresh water is lower than many other countries. Water availability has recently become a problem for some cities in Malaysia due to the heavy dependence on surface water from reservoirs which run low in the dryer seasons, as well as the local tendency to consume water indiscriminately. A Wolrd Health Organization guideline for water consumption gives a reasonable consumption rate of 165 litters per person per day, where as Penang hit 296 litters per day in 2013 (Abdullah 2015).

[5] According to Abushammala 5 of 14 sanitary land fills sequestered methane as of 2010

[6] 1.5kg waste/pax x 1ton/1000kg x 33M pax x 1.2 ton CO_2/ton waste / 0.5 = 43.3M tCO_2

4.9 WASTE WATER

Similar with fresh water there are emissions related with the required waste water treatment infrastructure, but the largest component of waste water emissions comes from the anaerobic decay of organic components in sewage, which results in the evolution of methane. In Figure 6 it can be seen that industrial waste water effluent accounts for close to half of all waste emissions, making it a very significant factor.

Sub-Sector	2020		
	BAU	PLAN	AMB
Solid Waste Disposal Sites	12,479.32	11,526.71	9,340.96
Biological Treatment of Solid Waste	0.32	0.32	0.32
Incineration	49.96	49.96	49.96
Open Burning	5.25	5.25	5.25
Domestic Wastewater	2,118.63	2,118.63	2,118.63
Industrial Wastewater	17,768.88	16,858.43	16,787.38
Total Emissions	**32,422.35**	**30,559.29**	**28,302.49**

Figure 6 *Three GHG Emissions projections (Business as Usual, Planning and Ambitious) to 2020 (BUR 2017) from Waste sub sectors*

5. HOUSEHOLD EMISSIONS MODEL

With knowledge of a few factors we can build an emissions model of a typical Malaysian household[7]. This can then be generalized, with some adjustments, to a city, and compared with local or nationally known emissions factors. To start the model, it is necessary to know the number of occupants in the house, and details of its construction. For this model we'll use a landed, single story, single family dwelling of cement block construction housing five people. The house is a 50 x 26 foot structure with 10 foot high, single brick walls, one foot beams, and cement roof tiles. Concrete is one of the highest emissions components in most residential structures, thus we will simplify the analysis of the building by limiting it to just the concrete used. A detailed floor plan of the model structure is shown in Figure 7.

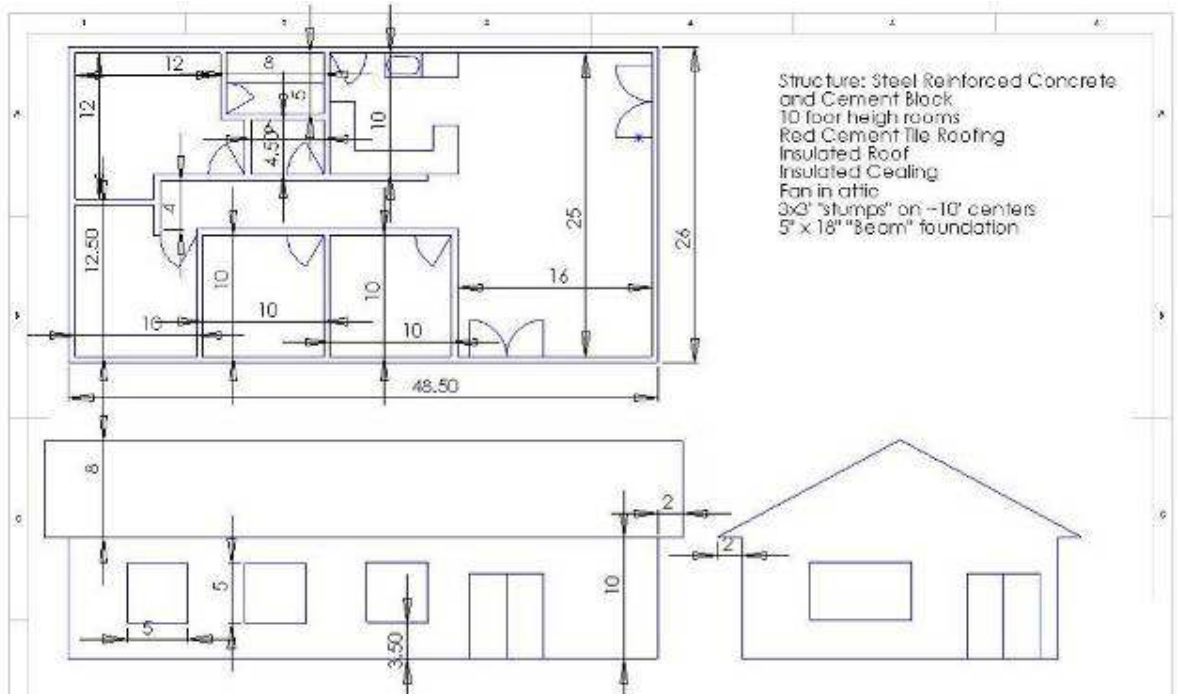


Figure 7 Model house used in the calculations. Dimensions are in feet.

Based on the single brick wall thicknesses, including the floor and roof we get a total concrete volume of approximately 70 cubic meters (Figure 8)[8]. The CO_2 emissions from the manufacture of concrete is estimated to be about 410 kg per cubic meter of concrete (Samarin 1999). This gives a total CO_2 emissions of over 28 tons for the structure. If we assume a useful life span of 80 years for the structure, then the annual emissions is then about 357kg CO_2e per year of occupation.

HOUSE CONCRETE VOLUME CALCULATION		
House Length	50	foot
House Width	26	foot
Wall Height	11	foot
Wall Thickness	0.5	foot

[7] Average household area in Malaysia was estimated to be 1264 sq ft (Tan 2019) with approximately 4 occupants (Hirschmann 2019), however our survey indicated 4.8 occupants per household

[8] Total volume is a summation of stump, floor, roof, exterior and interior wall volumes. Doors and windows have been neglected.

Roof Thickness	0.1	foot
Interior Wall Length	108	foot
Stump Volume	14	cu ft
Stumps	18	number
Total Volume	2462	cu ft
Total Volume	70	cu meters
Concrete CO_2 Emissions	410	kg/m3

Total Emissions (concrete)	28584	kg
Expected House Lifespan	80	years
Annual Emissions	357	kg CO_2
Monthly Emissions	**30**	kg/month

Figure 8 Concrete Volume and CO_2 Emissions Calculation for the house structure.

Next we want to examine green house gas emissions relating to the consumption of resources within the household. For the family of five where meals are mostly cooked in-house a 12kg tank of LPG might last about one month, giving an LPG consumption of about 2.4 kg per person per month. A typical electrical bill for a house with two units of air-conditioning might be around 220RM, which at the residential rate of 0.34RM per kWh would be 653 kWh per month. At a per-capita daily consumption of 200 liters a family of 5 will consume about 30,000 liters per month (Abdullah 2015). This results in a similar amount of waste water, which will be analyzed in the following section. To convert these to CO_2 equivalent emissions, we require the various emissions factors as shown below in Figure 9.

Internal Consumption		
Inhabitants	5	Pax
LPG Cooking Gas	12	kg/month
LPG CO_2 Conversion Factor	3.026	kg/kg Fuel
Cooking Gas Emissions	**36.3**	kg/month
Electrical Power Consumption	653	kWh/month
Electricity CO_2 Conversion Fact.	0.645	kg/kWh
Electrical Power Emissions	**421**	kg/month
Fresh Water Consumption	29600	liters/month
Fresh Water Conversion Factor	0.38	kg/1000liters
Fresh Water CO_2 Emissions	**11**	kg/month

Figure 9 CO_2 Emissions from the consumption of various resources

For combustion of LPG we can get the CO_2 emissions factor 3.026 kg CO_2/kg LPG from chemistry as explained above. The electric power emissions factor depends on the actual grid power sources in use at the time. For this model we are using 0.645 kg CO_2/kWh (MGTC 2017) reflecting the Malaysian power production mix as of 2017. Water supply emissions are mostly related with pumping power requirement, however there are unaccounted for effects from reservoir displacement of forest and etc. The conversion factor of 0.137 kg/1000 liters of water presented by Presura is likely an underestimate for these reasons (Presura 2017). The UK Department of Energy and Climate Change provides a factor of 0.344 kg/1000 liters (DECC 2016) and Wahid used 0.38 kg/1000 liters for Malaysia (Wahid 2019). As the UK, like Malaysia, is a relatively rainy country and knowing that the Presura number is likely an underestimate, we'll take the higher figure (0.38 kg/1000 liters) for fresh water supply CO_2 emissions. Using these factors, and the consumption numbers derived above we get a monthly CO_2 emissions of 36.3kg from

cooking gas, 421kg from electricity usage, and about 11kg for fresh water usage for the household[9].

The main waste products of a household are waste water flowing into the sewage treatment system, and solid waste (garbage). While some of the fresh water used does not re-enter the waste water collection system, either due to evaporation or "spillage", we'll assume that the wastewater volume is the same as the fresh water supplied volume, or 30,000 liters per month. Solid waste estimates vary widely, but most sources put it in the range of 0.5 to 2.5 kg per person per day, with Saeed putting it at 1.5kg in Malaysia in 2009 (Saeed 2009). SW Corp gave a range of 1.3 to 1.4 kg per person in urban centers in Malaysia during an interview January, 2020. For this analysis we will take a mid-range number of 1.35 kg of solid waste generated per person daily. Emissions factors for wastewater are given by DECC as 0.708kg per 1000 liters of waste water (DECC). These emissions are primarily a result of anaerobic digestion of organic waste materials resulting in methane production, and thus are some what higher than the emissions associated with the fresh water supply. Again the major emissions component from solid waste disposal is methane from the slow, anaerobic digestion of organic materials occurring in disposal sites. Solid waste emissions factors depend heavily on the amount of materials being recycled and dump site gas collection, and can range from 1.2 kg CO_2e per kg of solid waste for sanitary landfills with no gas capture, to as low as 0.19 kgCO_2 per kg of solid waste for sites which collect and burn the methane (Barton 2008). As many of the dump sites in Malaysia do not yet have methane capture (Abushammala 2010), we'll take an average of these two extremes, for a solid waste emissions factor of 0.7kg/kg of solid waste.

Waste Products		
Domestic Wastewater	29600	liter/month
Waste Water Conversion Factor	0.71	kg/1000 liters
Waste Water CO_2 Emissions	**21**	kg/month
Solid Waste	203	kg/month
Solid Waste Conversion Factor	0.7	
Solid Waste CO_2 Emissions	**142**	kg/month

Figure 10 Domestic Waste products emissions

Using these factors we get a monthly emissions of 21kg CO_2e from wastewater, and 142kg per month from solid waste. One of the most important things to remember is that the estimate of GHG emissions from solid waste is relatively significant (higher than cooking gas utilization, fresh water supply, waste water or dwelling structure emissions) and strongly influenced by methane sequestration and flaring at the landfill site.

Transportation expenditures vary widely from house to house as mentioned earlier, depending ones economic statue, need to travel for work or school, and availability of alternative modes of transport. It has been established that typical annual mileages for passenger cars in Malaysia is on the order of 15,000km with fuel mileages of 9.5km/liter (Gitano 2017). Motorcycles tend to be more efficient, and are also used for shorter distances, achieving typical mileages of 45km/liter while accumulating around 5,000km per year. According to the Malaysian Automobile Association there were 13.3M cars registered on Malaysian roads in 2017, and about 13M motorcycles (MAA 2018). With a population of 31.5M that year, that works out to be about 2 motorcycles and 2 cars per five member household. For this analysis we'll assume that the household has one car and

[9] In each case the CO_2 emissions = Consumption number x CO_2 Conversion factor

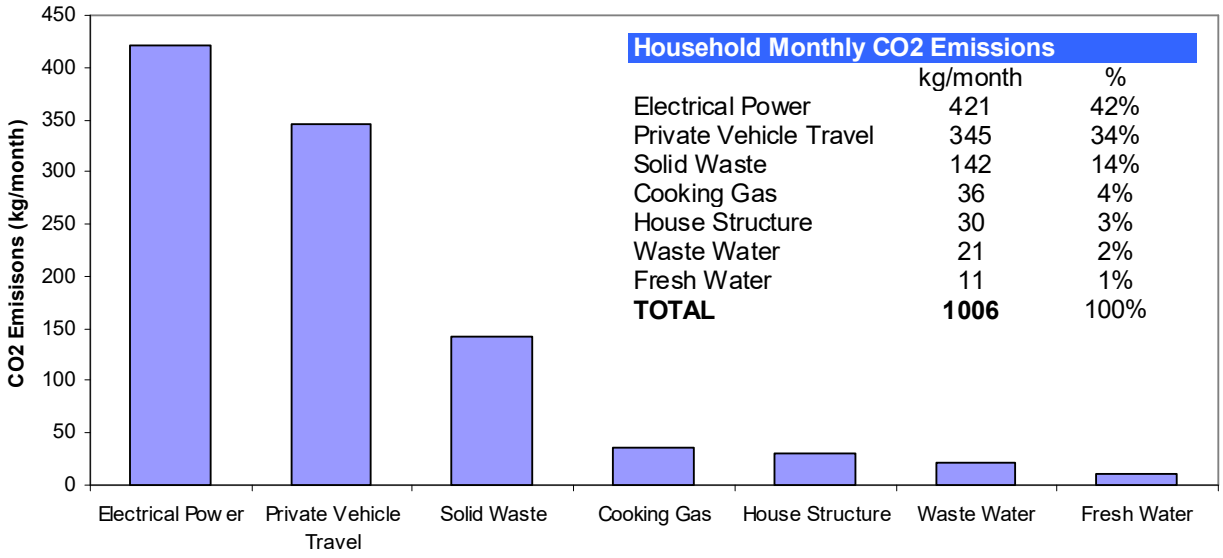
two motorcycles in operation daily. DECC gives an emissions factor of 2.30kg CO_2e per liter of petrol. Calculating out the emissions from the fuel consumption and annual range above, we get 303kg of CO_2 from car operation, while the two motorcycles contribute a total of about 43kg of CO_2. Again, there are likely to be wide variations in the actual emissions from one household to another, but it is clear from Figure 11 that transportation will be a major contributor to emissions from typical households. Also of note is that we have neglected other sources of transportation emissions, such as public transport, including taxis, or air travel. In general, public transport will yield much lower emissions (Gitano 2017), while taxis will actually tend to result in higher emissions per passenger kilometer. In general, however, Malaysians spend relatively little time in taxis compared to their own personal transport. Finally, air transport is not considered in this analysis as it is out of the boundary of the municipality.

Travel		
Car annual Range	15000	km/year
Car Mileage	9.5	km/liter
Pertol Usage	131.6	liters/month
Emissions Factor	2.3	kg/liter
Car Petrol Emissions	**303**	kg/month
Motorcycle annual Range (two)	10000	km/year
Motorcycle Mileage	45	km/liter
Pertol Usage	18.5	liters/month
Motorcycle Emissions	**43**	kg/month

Figure 11 Emissions from Personal Vehicle Usage

While there are a number of other sources of emissions related with individual households such as emissions embedded in food (which comes from a number of indirect sources, including the use of petrochemical fertilizers, deforestation to make way for crop land, emissions from the transportation and processing of foods, whole sale and retail outlet power consumption, employee transportation and etc.), other finished goods (eg. cloths, furniture) and services such as health care and entertainment, we will not focus on these here as they are largely out of the control of the municipality. As a reference, however, we will mention that according to (Jonse and Kammen 2011) overall emissions from food are the 3rd largest source after transportation and household electricity consumption.

Graphing the monthly emissions data by category, Figure 12, we can clearly see that the household's emissions are dominated by Electrical Power, which accounts for about 42% of all the considered emissions. Travel consumption is the next highest at 34%, followed by solid waste at 14%. The categories of waste water, cooking gas, emissions due to the construction of the house and fresh water supply all fall in the 1% to 4% range.



Household Monthly CO2 Emissions	kg/month	%
Electrical Power	421	42%
Private Vehicle Travel	345	34%
Solid Waste	142	14%
Cooking Gas	36	4%
House Structure	30	3%
Waste Water	21	2%
Fresh Water	11	1%
TOTAL	**1006**	100%

Figure 12 Annual Household CO_2 emissions by category

If we generalize these numbers to the national level, we can compare with some of the various national emissions analyses. Malaysia periodically publishes a report to the United Nations Framework Convention on Climate Change (UNFCCC) reporting on national level emissions, referred to as the BUR (Biennial Update Report). The latest (at the time of this report) version was published in 2018 with data from 2014. Population at the time of this inventory was 30.7M (MESTECC 2018). Total green house gas emissions for that year were 317.6Mt CO_2e. Unfortunately, this data is not broken down by sector or end use, so we have to make some assumptions about the fraction of overall emissions attributable to households. Taking our household estimates and multiplying by 12 months/year and dividing by 5 pax in the household, we get the emissions per capita in each category. If we then multiply by the 2014 population of 30.7M of the country, we can determine the fraction of the national emissions from each of the categories investigated[10], Figure 13, which in 2014 would have been approximately 74.2 million tones of CO_2, or approximately 23.3% of the overall emissions of the country.

Annual Percapita CO_2 Emissions	kg/year	
Electrical Power	1011	
Private Vehicle Travel	829	
Solid Waste	340	
Cooking Gas	87	
House Structure	71	
Waste Water	50	
Fresh Water	27	
PER CAPITA TOTAL	**2.42**	tCO_2/year
Population	30.7	M
Total Household Emiss.	74.2	Mt CO_2/year

Figure 13 Per-capita Annual Residential Emissions, and Total Household Emissions

[10] National Category Emissions = Monthly Household Emissions x 12 month/year x 30.7M pax / 5 Pax/household

One of the numbers directly comparable in the BUR is the emissions attributable to domestic waste water, which in 2014 was 1.64Mt CO_2. Our per-capita estimate of 50kg CO_2 from waste water becomes about 1.54Mt CO_2 at the national level, quite close to the BUR number.

According to the US EPA electricity production accounts for 25% of the global GHG emissions, while transportation yields 14% and buildings account for 6% as shown in Figure 14 (EPA 2019, IPCC 2014). In their definition of "Buildings" the US EPA is considering "on-site energy generation and burning fuels for heat in buildings or cooking in home". In Malaysia buildings are not heated, however many consume energy (from electrical grid) for cooling. If we take the bulk of the passenger car and motorcycle transport (70% of all road transport emissions) to be attributed to households, and knowing that road transport makes up about 85.3% of the total transportation emissions, we get 60% of all transport emissions attributable to private vehicles included in our model (Gitano 2017). Also, electricity is consumed by industry and commercial outlets as well as residences. According to data from Suruhanjaya Tenaga, residences accounted for 2,610 ktoe out of a total of 12,606 ktoe, or 21% of the total electricity consumption in Malaysia (ST 2017). Finally, the small contribution from building emissions can be divided among residential, commercial and industrial buildings. Residential buildings make up around two thirds of the buildings in cities, so we will assign this fraction of the building emissions to residences (SWH 2019). Thus, we would expect residences, as modeled in our analysis above, to contribute 21% of the Electrical Power emissions, two thirds of the building emissions and 60% of the total transportation emissions. Applying these factors to the EPA numbers we get about 18.7% of the total national GHG emissions attributable to the households.

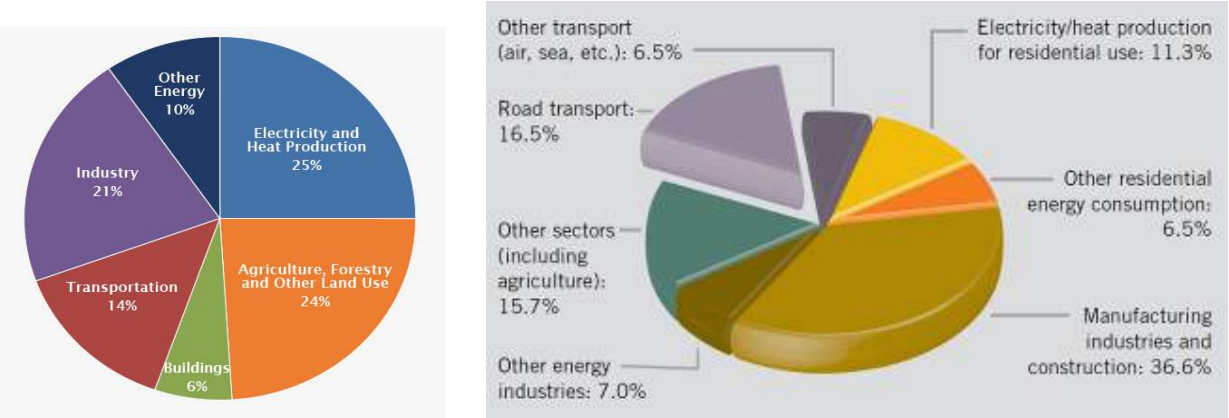


Figure 14 US EPA (left) and IEA (right) Sectoral breakdown of GHG emissions

The International Energy Agency uses different sectoral breakdown of emissions. According to IEA (Figure 14) approximately 17.8% of CO_2 emissions were produced by residences, while 16.5% is related to road transport (WHO 2011). Again, assuming that 70% of the road transport is personal vehicles (accounted for in our model) then a total of approximately 29% of the overall CO_2 emissions are attributable to residences (including personal transportation). Taking the average of the EPA and IEA numbers we get about 24% of the total emissions coming from the household categories analyzed in our model. The BUR gives a total national emissions of 317.6 Mt CO_2, thus at 24% the fraction attributable to households is approximately 76.2Mt CO_2. This compares quite well with the 74.2Mt CO_2 we have estimated from our "bottom up" household model. As mentioned previously, there are different definitions of what exact fraction of emissions can be attributed to the various categories, and significant variations in the emissions estimates at almost all levels. Given that the purpose of this analysis is to prioritize different emissions

mitigation actions, the difference between the model (74.2Mt) and top-down (76.2Mt) emissions are considered quite reasonable.

UNCERTAINTY IN EMISSIONS ACCOUNTING

Almost all emissions inventories depend on a large number of assumptions, with significant uncertainty in many aspects. Additionally, as we learn more about climate science and the effects of various gasses in the environment, the ultimate impact of green house gasses requires changes in our models. As there is no "one size fits all" accounting method, the choice of model or data must reflect the policy need being addressed. Expressing the effect of GHG's in CO_2 equivalent units is one simplifying factor universally recognized, even as the gas specific conversion rates are adjusted. While a complete data set, and perfect analysis may be illusive, we should strive to achieve a balance between precision and available resources. After all, the most important aspect of emissions modeling is to provide a *relative* assessment of various mitigation efforts in order to prioritize policy decisions. (Edenhofer 2014)

For easy comparisons of potential emissions mitigation actions we would like to have a standard emissions diagram. Taking the CAIT data for Malaysia from 2014, and neglecting the land usage changes, we can separate all emissions into the following sectors: Electricity, Transportation, Industry and Construction, Waste, Agriculture, and Other. Figure 15 shows the total emissions of Malaysia separated out into these categories based on CAIT data for Malaysia in 2014. Additionally, we have separated out transportation emissions into two categories: private vehicle road transportation of individuals and all other transportation, which accounts for approximately 50% each (Gitano 2017). If 50% of the electrical consumption is ascribed to residences, the other half we labeled as commercial, though it also represents municipal power consumption as well as other uses.

Careful examination of Figure 15 will show that it is in good agreement with our household model (Figure 12) which showed residential electrical consumption contributing more emissions than private transportation, and household waste is somewhat less than half that of private transport.

We will continue to refer to this emissions diagram for comparison purposes through out the rest of this report.

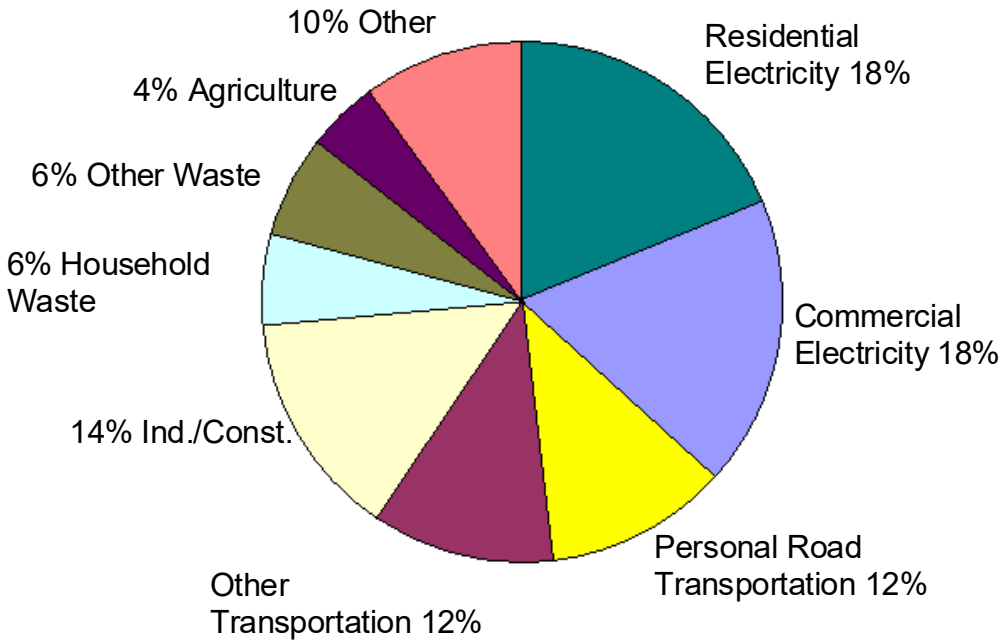


Figure 15 Nominal National Emissions broken down by category for Remediation Comparison.

For our reference year 2014 this represents a total emission of about 320 million tons of CO_2 per year. Of this we will ascribe the household waste, personal road transportation and residential electricity to the "household" in general, for a total contribution of about 36%, or about 115 Million tons of CO_2 per year.

6. CITIES CARBON FOOTPRINT

Many of the emissions factors of individual households are out of the direct control of the city. The electrical power generation mix, for example, is a matter of national energy policy beyond the control of individual municipalities. Cities can, however, take on an active role in controlling many of the emissions factors. For example, while vehicle ownership and usage are choices are made by the individual consumers, the city can actively encourage the use of smaller, more efficient vehicles, or even public transport via a wide range of different policies. Additionally, there are some factors, such as development and maintenance of urban green spaces, which are almost solely within the purview of the municipality. In this section we analyze the various emissions factors for their amenability to municipal control.

6.1 PARKS AND GREEN SPACES

Urban parks and green spaces not only enhance the lives of those living in the city, but they can also make a major contribution to GHG emissions reduction in a number of ways:

- Carbon sequestration via biomass
- Cooling effect from shading and evaporation
- Encouragement of pedestrian/non-motorized traffic

Living plants in green spaces actively convert atmospheric CO_2 into biomass. Estimates for large trees range from 0.29kg CO_2/m^2 to 1.55kg CO_2/m^2 of area covered by the tree annually (Groth 2008, Lee 2010, Wang 2015). Taking an average of the above we get 0.92 kg/m². Taking the Penang Botanic Garden covering 40ha as an example, we achieve an annual carbon sequestration of about 267 tons of CO_2 per year.

PARKS		
Tree covered spaces	0.92	kg CO_2/m^2 year
Park Area	29	hectare
Park Area	290000	m²
Annual CO_2 Sequestration	**266.8**	Tons CO_2/year

Figure 16 Example of CO_2 sequestration from Penang Botanic Garden,

Built up areas in cities often have a much higher ambient temperature compared to the country side. This is known as the “urban heat island effect” and is a result of reduced evaporative cooling and lower albedo (reflectivity) surfaces, especially asphalt, which absorb more heat from sunlight. The urban heat island can result in 5-10°C higher ambient temperatures in towns compared to rural areas. Trees shading buildings and other techniques can reduce the energy consumption of buildings adjacent to green belts by 2 to 20% (Akbari and Konopacki, 2003, Abdel-Aziz 2014).

Parks can also serve as pedestrian accessible destinations for leisure time activities, including lunching places for local retail, residential and office buildings. Green belts can act as pedestrian links between transportation hubs (train stations, bus stops) and living, working and shopping places. An excellent example of the use of green belts for encouragement of non-motorized

transport are the riverside bicycle paths in many cities, such as Fort Collins, Colorado USA, Figure 17. Many of the bicycle/pedestrian paths follow along side urban green belt waterways, and are completely separated from vehicular traffic. One can conveniently get to almost any part of the town within a few minutes on the many bike paths. This, of course, can significantly reduce transportation energy demand. The city has been perusing a “Bicycling master plan” for several years, and among the various aims is to get 20% of the population commuting by bicycle by 2020 (Ft. Collins 2014).). This includes 260km of semi-sequestered bike paths in the town, which measures only about 10 x 10 kilometers. Given the high bicycle usage in “collage towns” this is an achievable target. For example in 2014 Boulder Colorado recorded 10.2% of workers commuted by bicycle, and Fort Collins Colorado recorded almost 7% (Coloradoan 2014, Grunig 2014). Malaysian cities, however, have a “very low rate of cycling” for a number of reasons including car-oriented town planning, poor layout of bicycle lanes, long commute distances and hot/humid weather (Shokoohi 2017).

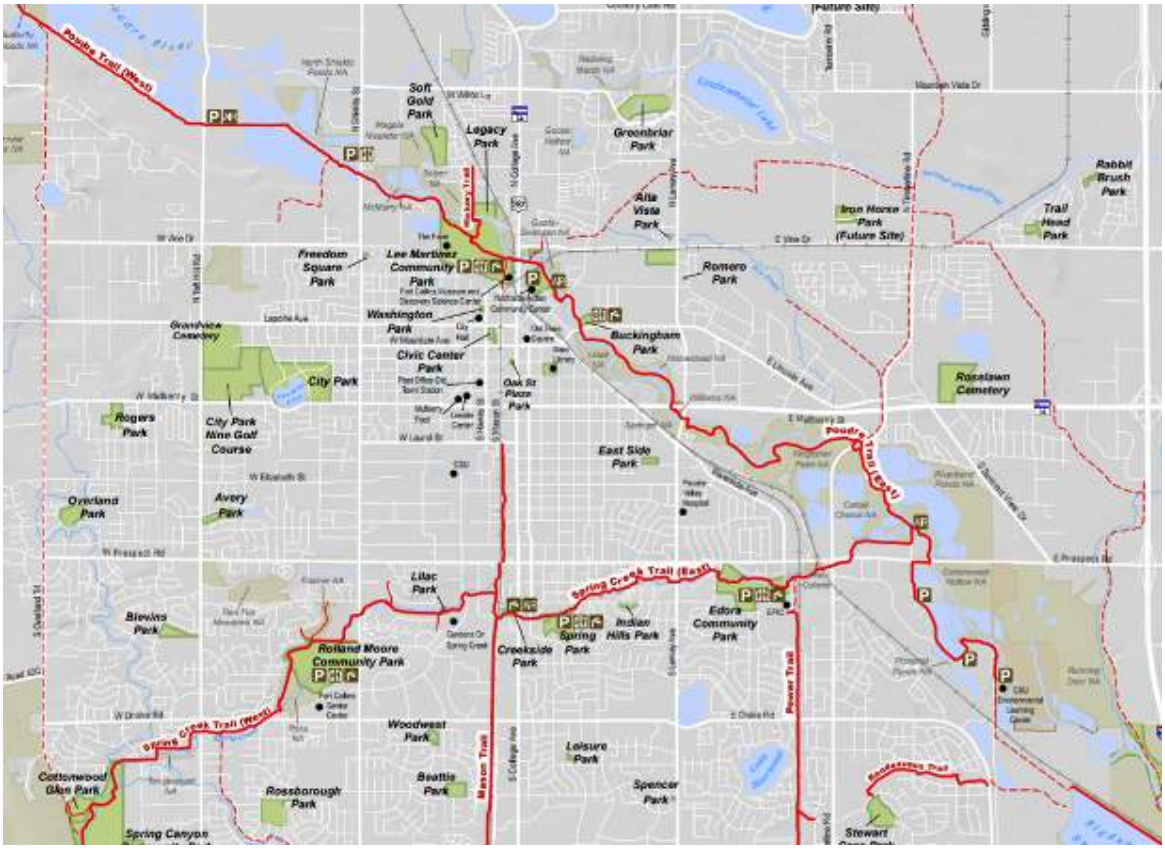


Figure 17 Bicycle paths in Ft. Collins, shown in red, allow easy access to the whole town.

To analyze the potential impact of urban green spaces we will have to look into each of the three major emissions effects of green spaces, namely carbon sequestration, cooling effect, and non-motorized transport. Based on the household model we have established an annual per-capita emissions of just over 2.5 tons CO_2 for a typical Malaysian. Urban centers were characterized by a population density of 3,300 people per square kilometer in 2010 (World Bank 2015). Taking this population density, and our per-capita emissions, we can calculate that urbanites generate about 8.335 tons of CO_2 per square kilometer annually. If we can convert 10% of urban spaces to parks or green spaces, this would give us 100,000m² of green space per kilometer. Using 0.92kg CO_2/m² sequestration would reduce the emissions by about 92 tons CO_2 per square kilometer

annually, or about 1.1% of the total household emission[11]. Converting ten percent of urban space to green areas is not as difficult as it may sound: sidewalks and shoulders of roads are ideal places for large trees, shading and cooling the road and walk ways, as can be seen in Figure 18.

Figure 18 Trees shading the streets of Lancaster, Pennsylvania USA.

If we assume that the 20% bicycle commuting target for Ft. Collins is reasonable for an urban center, this would remove about 166kg CO_2 per person or about 547 tons of CO_2 per square kilometer annually[12]. This represents a reduction of about 6.6% of an individual's household emissions.

The urban cooling effect is more difficult to quantify. Akbari and Konopacki estimated that urban structures could save 5 to 20% of their energy expenditure based on the shading and cooling effect of nearby trees (Akbari 2003). Understanding that the effect will only be felt strongly in close proximity to the green belt, we'll take a conservative estimate of 10% of energy savings. If the average urbanite expends 1086kg CO_2 annually on electric power, a 10% reduction would save 109kg of CO_2 per person, or about 358 tons CO_2 annually per square kilometer[13]. This amounts to about 4.3% of the typical urbanite's emissions.

Combining the effects of CO_2 sequestration in biomass (92 ton/km²), non-motorized transport enhancement (547 ton/km²) and cooling effects (358 ton/km²) we get a total CO_2 reduction of around 998 tons CO_2 per square kilometer annually from urban green spaces. According to the World Bank, Malaysia incorporated about 4600 sq km of urban area in 2010 with a 1.5% growth rate (World Bank 2015). In 2014 this would yield 4882 sq km of urban space. If green belts can

11 (100,000m² x .92kgCO_2/m² x 1ton / 1000kg) / (3300pax x 2.5tonCO_2/pax) = 1.1%

12 0.2 x 829kgCO_2/pax x 3300 pax/km² x 1ton/1000kg = 547tonCO_2/km²

13 0.1 x 1086kgCO_2/pax x 3300 pax/km² x 1ton/1000kg = 358tonCO_2/km²

reduce emissions by 998 ton/km², then Malaysia's overall emissions in 2014 would have been 4.8Mton CO_2e lower[14] if 10% more of the urban space was converted to green belts, giving an approximate 1.5% reduction in national emissions (Figure 19). This assumes that 10% of the urban area is devoted to trees or green belts, and that the green belts have a fairly significant effect on cooling adjacent areas and reducing motorized traffic by 20%.

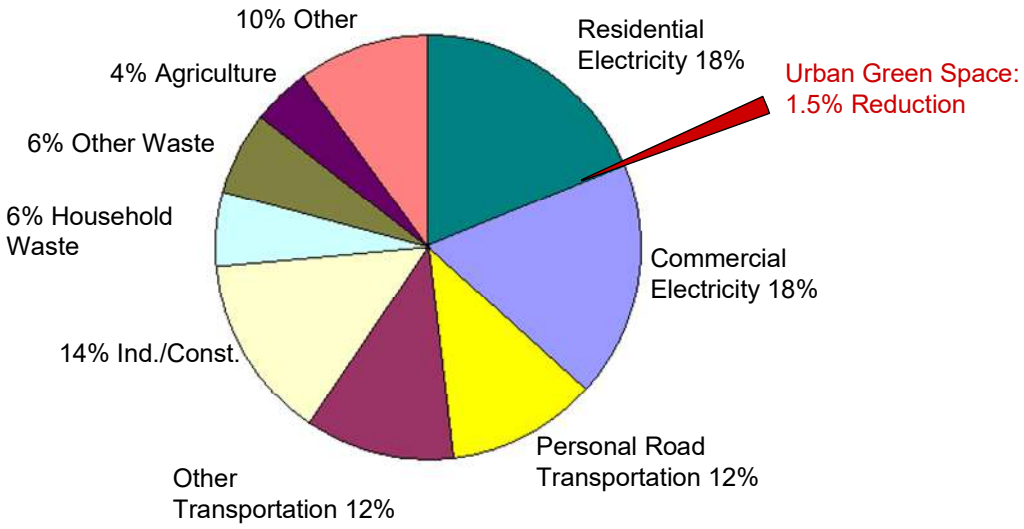


Figure 19 Emissions Reduction Potential of 10% Greater Urban Green Space

6.2 INDUSTRIAL EFFLUENT

A second category of emissions neglected by our household level analysis are the emissions from industrial effluents. This is a very difficult area to generalize as different towns will have a different mix of industries, with widely varying effluents. Additionally, many of the most polluting industries are generally located outside of city boundaries. None the less, Malaysian cities often include industrial zones where various industrial processes generate emissions. While a complete review of industrial emissions is beyond the scope of this study, here are a few of the higher emitting industrial processes (EPA 2018):

- Iron and Steel Production
- Cement Production
- Petrochemical Production
- Refrigerant Production
- Aluminum Production
- Lime Production
- Ammonia Production
- FS_6 (used in electrical transmission systems)

The Malaysian BUR reported an annual CO_2 emissions of 15.8M tons CO_2e from industrial waste water alone, or approximately 5% of the total emissions from the country. One of the major contributors to this comes from Palm Oil Mill Effluents (POME). Similar to domestic solid waste,

[14] $4600km^2 \times (1.015)^4 \times 998tonCO_2/km^2 = 4{,}800tonCO_2$

POME results in significant amounts of methane generation from the decay of organic materials in the effluent (MESTECC 2018). In the case of palm oil mills, there is a unique synergy as they require a large amount of heat energy for the processing of palm oil, and have a readily available source of energy in the form of the methane from degradation of waste products. A complete review of every possible industrial process and potential emissions reductions are beyond the capacity of a municipality to effectively track. Knowing, however, that certain industries, especially palm oil mills, paper mills, or any other industry generating a large amount of organic effluent, as well as industries dealing with high GHG potential materials (such as CFCs), may be major GHG contributors, these particular industries should be rigorously investigated by the municipality for compliance to all existing environmental standards, and reformed if found to be in violation. How large a contribution this may have to emissions reductions is impossible to say with out going into an in-depth case-by-case analysis.

6.3 TRANSPORT

Transportation is the second largest GHG contributor from urbanites according to our study. Of course the ultimate emissions from transportation in a given city is subject to a number of different factors, largely the individual consumer's choice of vehicle, choice of where to live and work, where to go to school and etc. The municipality, however, can have a strong influence on these decisions, and in fact the actual amount of travel required. While some travel is for entertainment and may be unpredictable, most of the transportation requirements of city dwellers is relatively easy to analyze: essentially they commute to work, school, shopping facilities, and perhaps religious ceremonies. While individuals may live in any given part of a city, and work in another, there are recognizable concentrations dwellings in "*taman*" or residential areas, as well as concentrations of industrial jobs in industrial parks, commercial jobs in retail centers and such. Efficient cities provide required support facilities such as schools, governmental offices, and clinics, in close proximity to residential concentrations in order to reduce the need for travel. Additionally, these should be connected by public transportation systems to provide an appropriate alternative to private vehicle travel. Large scale industrial zones in isolated location (for example Kulim High-Tech in Kedah, Figure 20) necessitate the transport of many workers from home to work and back again each day.

Figure 20 Kulim Hi-Tech industrial park in Kedah, Malaysia

A more efficient design has industries interspersed in proximity to population centers, reducing the need for long-distance travel, as well as “rush hour” road congestion on the industrial access routs. In Figure 21, we can see the south east corner of Penang Island, with the Penang International Airport cutting diagonally between the Bayan Lepas Free Trade Zone (FTZ) at the lower right, and various red roofed residential areas on the upper left.

Figure 21 Penang Airport and the Bayan Lepas Industrial Zone

Each day tens of thousands of workers have to commute from the various living quarters (many of which are not shown in the figure) into the FTZ. This forces them all on to the same few roads squeezing around the airport on the north, as indicated by the red arrow. Obviously these roads will be subject to massive “rush hour” jams. Personal automobiles are a relatively inefficient way to travel to begin with, and achieve their maximum fuel economy at speeds near 90 kph (ORNL 2019). When stuck in traffic a car’s fuel consumption, and thus GHG emissions, can easily increase by a factor of four. Good urban design to prevent traffic jams should be a high priority for any municipality wising to improve its overall emissions and sustainability.

For contrast Figure 22 shows an industrial center in the city of Düsseldorf, Germany. The industrial zone is the large area of light-colored roofs in the center. Notice that it is surrounded by green spaces, and residential areas, allowing easy access for the workers. Another thing which can’t be seen in this image is that there are over 30 S-bahn and U-bahn (surface and subway trains) stops in this image which covers an area of approximately 5 x 5 km, the same size as the image of Penang in Figure 21, which has no commuter trains at all.

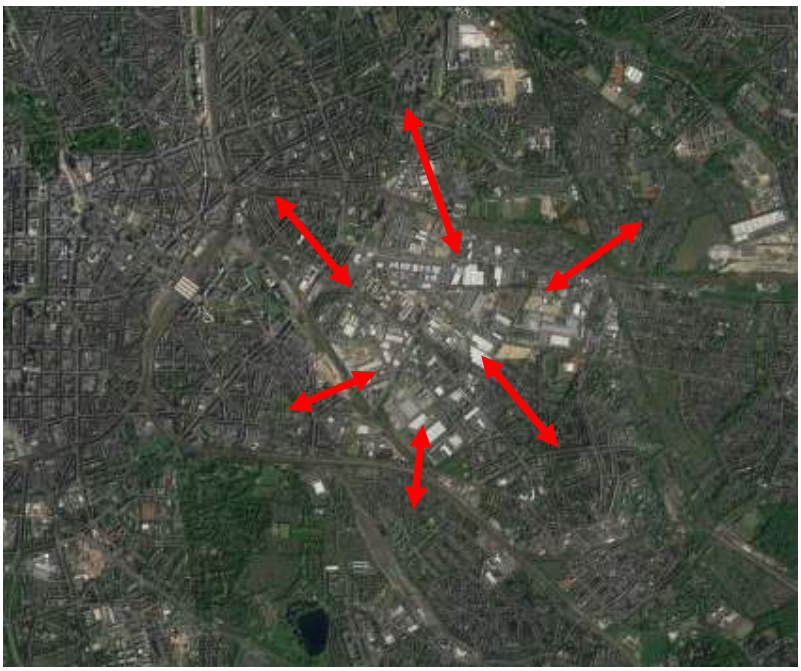


Figure 22 An industrial zone in Düsseldorf Germany surrounded by residential areas.

The fundamentals of traffic emissions reduction in cities consists of various aspects of urban design, public transportation alternatives, and incentivizing efficient habits.

The basics of efficient urban transportation planning are well documents and include the following aspects:

- Town planning for efficient layout of Residential, Industrial, Commercial and Government centers
- Mass Transit Routes serving major centers, with feeder lines to the periphery
- Inter-Hub connections (this is conspicuously absent in many Malaysian cities)
- Free urban buses
- Incorporation of Non-motorized Transport

- Congestion Taxation
- Encourage smaller more efficient vehicles, including 2-wheelers

As mentioned, good town planning requires designing a city's layout from the beginning with transportation efficiency in mind. People should have short distances to commute to work and school, retail and commercial centers. Each neighborhood should have a local transportation hub linking it with longer-distance transit options. For someone to use public transport the whole door-to-door trip must be considered. Simply getting someone on a bus does not necessarily get them to their destination if it is not connected to the rest of the public transport network. One of the keys to this is to link together all the transportation hubs serving a city with the common origination and destination points. For example, there should *always* be an express link from the local airport to the town center, to the bus station and the local long distance rail station. Preferably these should have sequestered lanes to avoid conflict with other surface traffic. This is one area which urgently needs attention in many Malaysian cities. While Malaysia is good at building new train stations (eg. Penang Central) or bus stations (Aman Jaya in Ipoh) these are often not connected directly to the town center (a fault shared by both Ipoh and Penang), or to the local airport (again this effects both) or the local bus/train station (Ipoh).

To prevent congestion, it is often relatively cost effective to provide free urban center shuttle buses keeping people out of cars, and keep cars out of traffic. Similarly, convenient pedestrian or bicycle links should be provided for to access transportation hubs. In Kuala Lumpur's Transportation Oriented Development (TOD) the plan is to provide at least 400m of covered walk ways from each LRT/MTR station (KPKT 2016).

Cities have a powerful tool in the form of taxes which can be levied against inefficient transportation practices, such as single occupant cars on congested roads in rush hour traffic. Singapore is one of the best examples of a city which has been very effective at utilizing behavioral changes to influence transportation. This city of 5.6 million people only has about 600,000 private cars (LTO 2018), with an average accumulation 17,500km per year (LTO 2014), this come out to about 1,900km per person per year. The same number for Malaysia is four times that at about 7,600km per person per year[15].

Determining exactly how much transportation related emissions can be reduced is complicated. For reference we can compare countries with similar demographics, but different transportation related emissions. According to a comparative study of emissions the USA and Germany have many similarities including high GDP and standard of living, high rates of vehicle and drivers license ownership, and important domestic automobile manufacturing industries (Buehler 2012). However, ground passenger travel emissions in the USA are about three times higher than in Germany. The major differences are related to differences in town planning, vehicle efficiency and public transport. Americans tend to drive larger vehicles (SUV and pickup trucks), their towns are sprawling with residential areas generally devoid of any commercial or other services and public transport is less common (Lowery 2011). Germans, on the other hand, tend to drive smaller more efficient vehicles[16] when they drive, especially turbo diesel powered cars, their towns are much more compact[17], and amenable to public transport, which is very popular (ICCT 2019).

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15 13,288,797 cars in M'sia x 18,000km/year / 31.5M pax = 7,600km/pax per year

16 Average car weight in Germany is 1477 kilos, while in the USA it is 1,822 kg (ICCT 2019, Lowery 2011)

17 Munich Germany has a population density of 4,700 pax/km² whereas Denver USA has a population density of 1,745 pax/km² (Source: Wikipedia)

Malaysia has a high urban population density[18], our towns are more compact than American cities, and have a better mix of retail/commercial outlets even in residential areas (where local stores, or *kedai runcit,* are almost always available); however, there is a trend toward driving larger and larger vehicles, with the SUV class growing rapidly from 3% of the market in 2010 to 23% in 2019 (Hans 2020). Public transport is only heavily utilized in a few select areas, and Malaysia has a love affair with large industrial zones devoid of housing and commercial space. Thus, while a reduction of transport emissions by a factor of three might be unrealistic in the short term, a reduction of 50% of private vehicle emissions might be possible. After all, it was hypothesized in the section on parks and green spaces a reduction of transportation emissions by as much as 20% could be possible, and switching from cars to motorcycles, highlighted in previous studies as having a major impact on transportation emissions (Gitano 2016), would reduce emissions by almost 80%. The modest goal of reducing private vehicle emissions by 50% would reduce the national emissions by approximately 6% (Figure 23). While switching from cars to 2-wheelers can have a major impact on emissions, it also raises the concern of safety. Thus any move to increase the transportation share by motorcycles should also look into improving the safety of these higher risk vehicles.

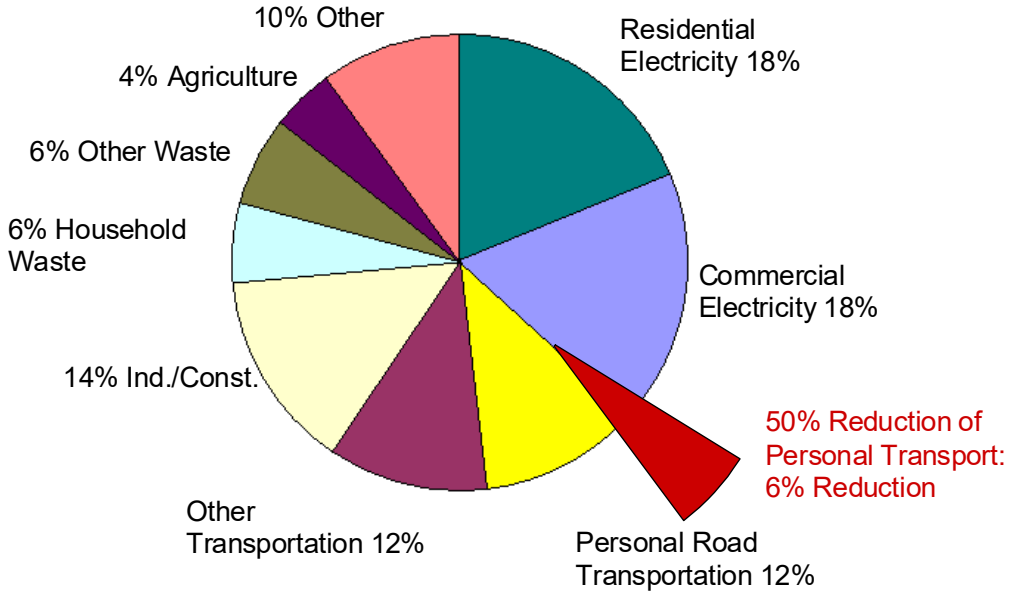


Figure 23 Emissions Reduction Potential of a 50% Reduction in Private Transport Emissions

6.4 BUILDING THERMAL EFFICIENCY

Building energy consumption in tropical countries differs significantly from that of most western countries which are located at higher latitudes. In these cooler climates buildings generally require heating to maintain a comfortable indoor temperature for a significant part of the year. In contrast, buildings in tropical countries historically have been designed to allow good air flow (to reduce molding) and heat rejection as shown in Figure 24 (Yuan 1987). The *Atap* houses feature an insulating roof, and "chimney" ventilation, a combination of roof and shutter shading of windows with ample diffused or indirect lighting. What's more, as traditional Malay villages were often sited near rivers and estuaries, they were generally supported on posts around two meters off the

[18] Petaling Jaya has 6,600 pax/km², Source: Wikipedia

ground to prevent damage during floods, and providing additional ventilation and they were very often surrounded by trees.

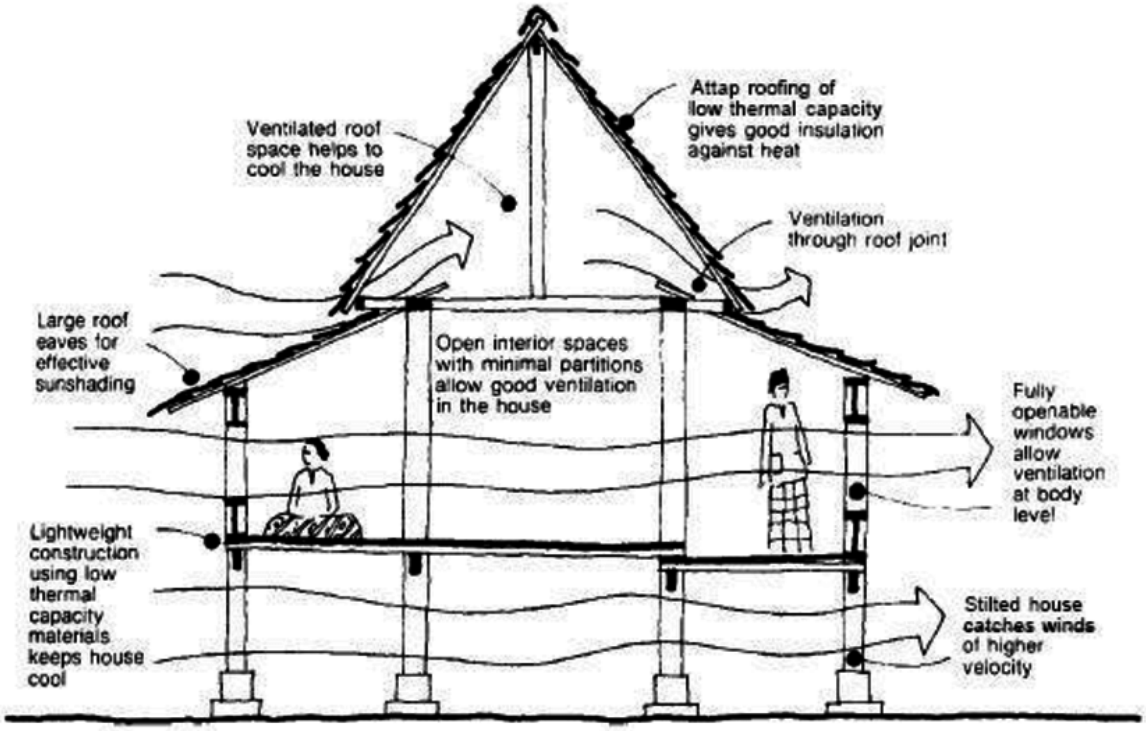


Figure 24 Traditional architecture effectively cooled and ventilated the living space.

Unfortunately, “modern” architecture has largely abandoned these environmentally sound designs in favor of permanent construction of steel reinforced concrete and cement bricks, ceiling fans, and increasingly, air conditioning systems as seen in Figure 25. The highly evolved traditional house architecture has been replaced almost exclusively by ground level single and multi story concrete block buildings with little or no insulation or roof ventilation. This is largely driven by developers as a cost saving measure. Consumers are generally unaware of the value of insulation or efficient building design, thus would be skeptical about spending more money on a well designed and built house. From our surveys only 7% of the households responding indicated that they had insulation in the attic space.

Figure 25 A common site in Malaysian cities: external walls covered with air-con units.

Based on our surveys (presented in the next section), most Malaysian households now have two or more air-conditioning units, and this typically adds around 165 RM per month to the electrical bill, or almost 500 kWh of electrical power consumption each month. Generalizing this to the whole of Malaysia, home air conditioning accounts for about 35M tCO_2e per year, or approximately 11% of the total national emissions. This may be an over estimate as the rates of air conditioning, and power consumption are lower in the country side, but helps to emphasize the importance of residential air conditioning emissions.

Although national building standards exist (eg. MS1525), which include provisions for roof insulation, passive cooling design, lighting and etc, local authorities often do not confirm conformity, and as a result a large number of buildings, both residential (eg. Taman Sempadan in Parit Buntar, Perak) and commercial shop lots (eg. Taman Jawi Indah, Penang) are built with no roof insulation or ventilation at all. This results in exceedingly hot interior temperatures, especially on upper floors, which retain the heat in the thick cement walls. As 50% to 85% of the solar heating of a house comes in via the roof, improving heat rejection of the roof can have a great effect (Chan 2009). Estimates have shown that electricity consumption can be reduced by as much as 50% with the use of roof insulation and attic ventilation alone (Parker 2005)[19]. From our surveys we established that Malaysians spend almost 70% of their electrical bill for air conditioning. Reducing this by 50% represents an emissions reduction of about 6% for the whole country (Figure 26).

[19] For reference the head quarters of Focus Applied Technologies went from spending 0.46RM/sqft per month for air conditioning to 0.22RM/sqft with the use of insulation and attic ventilation.

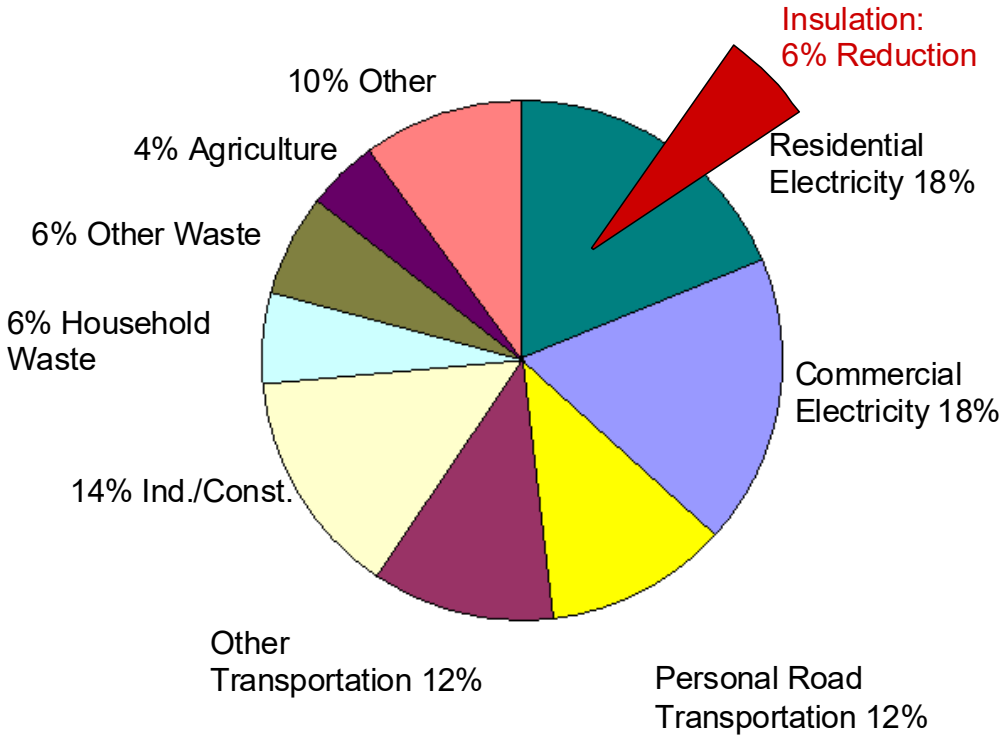


Figure 26 Emissions Reduction Potential from Improved Residential Insulation

Additionally, the mandatory use of insulation and efficient building design is a win-win scenario: the cost of the insulation is rapidly recuperated in reduced electrical consumption. 50mm of fiberglass insulation and a reflective Mylar radiation barrier adds less than 1000RM to the cost of a typical Malaysia dwelling (as detailed in Figure 7 earlier). If a monthly savings on air-conditioning of 60RM is realized, it would take under 18 months to pay for itself, and this calculation excludes the increased comfort of the occupants from the lower interior temperature.

Many aspects of a building affect the buildings energy efficiency. Some of these, such as using a light-colored roof, can be achieved at no additional cost to a building. Considering thermal comfort and the required cooling energy the following have been highlights as major contributors (Chan 2009):

Building orientation
This affects both the solar heat ingress, and ventilation (depending on prevailing wind).

Building Internal Layout
Position and heights of the various internal spaces can affect heat ingress.

Roof System
Roof color, insulation, venting and wall shading are very important factors as typically 50 to 85% of the solar heating of houses in Malaysia enters through the roof

Building Material Properties
Interior temperatures are affected by the thermal resistance, surface convective coefficient, absorptive, reflectivity and emissivity of the surface and heat capacity of the bulk building material.

Windows
Window type and size, type of glass, tinting and shading are all factors affecting thermal ingress through windows.

Construction Details
Cold air leaks, and heat conduction bridges in structures can also affect heat ingress.

Landscaping
Planting of shading shrubs and trees around a building will help reduce solar influx.

6.5 SOLID WASTE METHANE SEQUESTRATION

Most of the GHG emissions from solid waste are related with anaerobic digestion, evolving methane, and to a lesser extent CO_2 and nitrates. The simplest solution is to sequester the methane and burn it, preferably for power production or use in some industrial process. This can reduce the emissions per kilogram of solid waste from our assumed 0.7kg (open dumping) to 0.19kg (Barton 2008), a 73% reduction. As solid waste was the third highest category of household emissions, landfill methane sequestration would reduce the national emissions by about 4.5%[20].

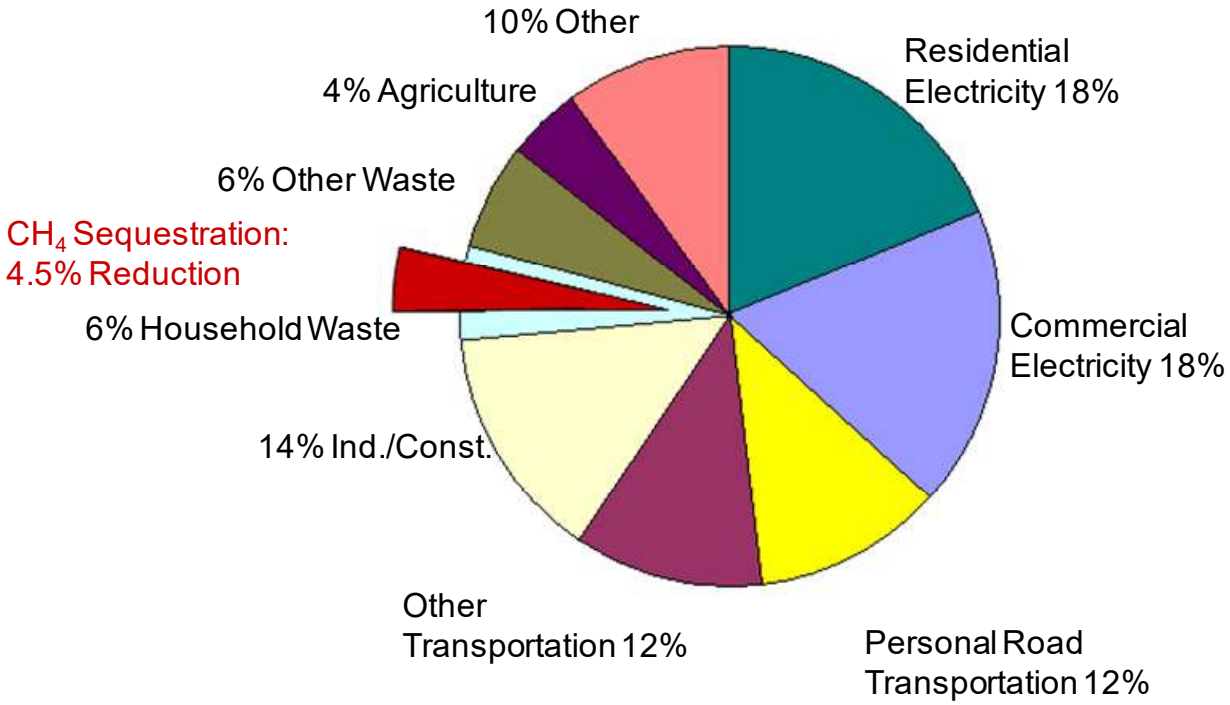


Figure 27 Emissions Reduction Potential from Land Fill Methane Sequestration

Landfill outgassing is the 3rd largest contributor to methane emissions (EPA 2017). Landfill methane sequestration is a well understood, mature technology which can reduce the cost of operation of a landfill (EPA 2020). Implementation in Malaysia, however is hampered by a number of factors, including the long lead time required to implement this at a given dump site, the financial investment required, and frustratingly, a lack of direct authority over its implementation (Pemandu 2015). Given the large impact, and existing systematic issues, this is clearly an area ripe for further intervention.

[20] 6% household waste x (1 - 0.19/0.708) = 4.5%

6.6 RECYCLING

Recycling is often considered an “easy win”, however it necessitates significant changes in individual behavior, requiring long-term public awareness building and consistent and effective facilities for recyclable material collection and processing. One of the keys to effective recycling is to get the recyclables separated from land-fill destine waste at the generation site, that is at the household or wherever the materials are initially discarded. This requires having a clear definition of what materials are to be recycled, and designated containers which must be monitored to insure they are being properly used. The current initiative was started back in 2016 (paper waste in blue bags, plastic waste in white bags while other recyclables like glass, electrical items and aluminum tins placed in green bags) appears to be moving slowly in the right direction, however vast areas of the country are not included in this exercise (Clean Malaysia 2015). Successful recycling can easily reduce landfill volumes by over 30%, where as in 2015 Malaysia was recycling only about 10% of its solid waste (Pemandu 2015).

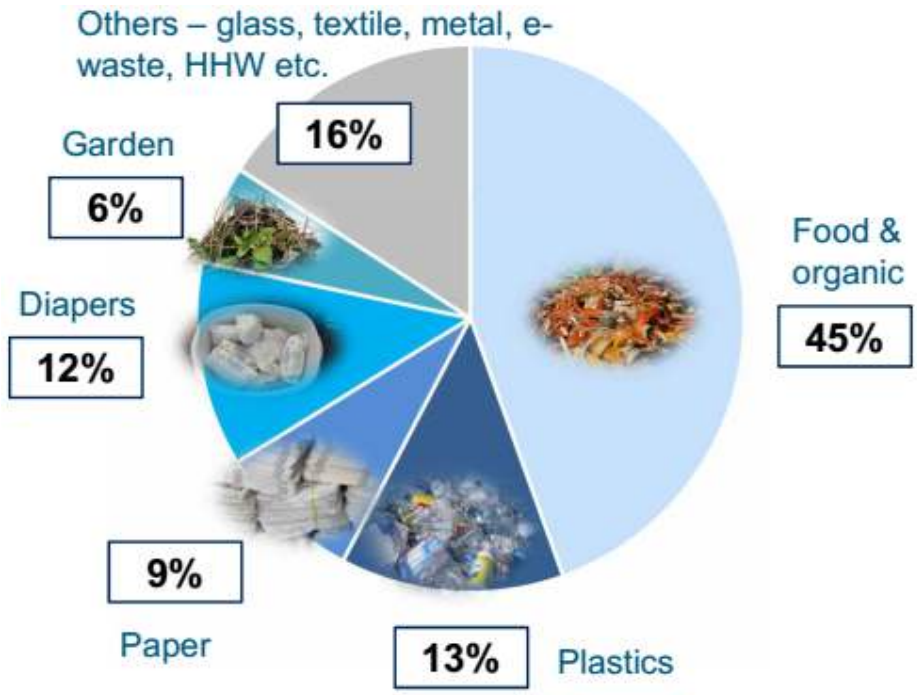


Figure 28 Residential Waste breakdown as of 2012 (Pemandu 2015)

The more precious materials such as steel, aluminum and lead, are routinely recycled. Additionally in urban areas there are often informal scrap scavengers who collect plastic, and paper. This model relieves the burden on the end consumer to some extent, as the scavengers will often show up at the door of a residence, and even separate recyclables from refuse.

Interestingly, although food waste, organic matter, and garden waste comprises around 50% of the total household refuse (Figure 28), very little effort is focused on this. In rural areas food waste is sometimes passed on to chickens, and then interred as fertilizer for crops or fruit trees. However it is not uncommon to see large amounts of “garden waste” and obviously useful food waste (such as coconut shells from “Fresh Coconut” stands, Figure 29) being placed at trash collection points. As organic material forms such a large percentage of the residential solid waste, and is also useful as fertilizer, this is clearly another area ripe for intervention. Some localities

such as Petaling Jaya, have begun programs for on-site composting of waste food and organic garbage (Sørencen 2010). This can have a great impact on CO_2 emissions: where as land filling household waste without methane capture can contribute up to 1.2kg of CO_2 per kilo of waste, Chan et. al determined that small scale composting resulted in only 0.0043 to 0.0062 kg of CO_2 per kilo of waste (Chan 2010). What's more, composting at the "local" level, either household or neighborhood, reduces the emissions from transport and processing of the waste materials, and can reduce the need for petrochemical fertilizers. The national impact of this could be as much as 2-3%[21].

Figure 29 Discarded "Fresh Coconut" husks sometimes wind up in the garbage

6.7 FOOD, AND GENERIC RESOURCE CONSERVATION

Reduction of consumption in general is one of the keys in reducing emissions: only consuming what you need reduces the amount of raw materials required, as well as the burden of disposal of waste materials. Unfortunately, this is in direct contradiction of human nature which is concerned with social currency, driving individuals to *consume as much as you can* (Shumacher 1973, Rostow 1960). Individuals are strongly influenced by their social standing which is based largely on what resources they own or control. Various "luxury" items, such as expensive cars, hand bags and bungalow houses are widely recognized as status symbols, and thus much sought after by individuals craving social recognition. Overcoming this will be a demanding task, however it is critical considering the GHG ramifications.

Excessive food wastage, especially related to festival seasons and group activities (eg. conference banquets) has consistently been highlighted as a significant GHG contributor. For several generations education in the west has stressed conservation of food, with children being taught that wasting food is a "sin". Public awareness about food conservation is only just

[21] 6% x 0.45 x (1 - 0.006/1.2) = 2.7%
NOTE: This excludes effect of the use as fertilizer

beginning in Malaysia and will require an ongoing commitment to raise awareness and effect a significant change.

7. HOUSEHOLD SURVEY RESULTS

Primary data relating to GHG emissions is often difficult to obtain. When it does exist, sometimes it may be unreliable due to differences in classification, or simply unavailable at the finer geographic resolution required to investigate a given city. In order to place some bounds on given emissions categories, we developed a survey questionnaire for individuals. Generally, we targeted the head of the household who would have knowledge of the parameters we were especially interested in. The questionnaire (Figure 30) was developed through several iterations based on feedback from actual respondents. A larger version is available in Appendix 2.

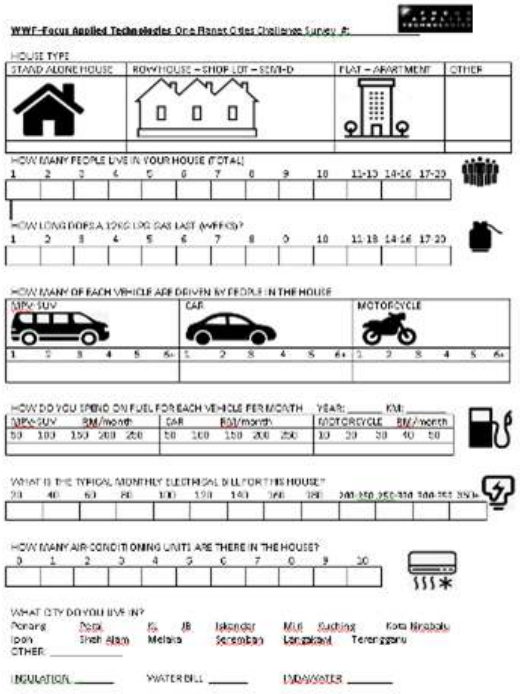


Figure 30 Individual Household Survey form

Surveying an individual generally took about four minutes to explain each of the categories and get the appropriate data. During the surveys we asked respondents what type of house they lived in (Landed house, Shop Lot/Row House/Semi-D, Flat or Apartment), and how many people lived in the dwelling. Cooking gas usage was estimated in the number of weeks a 12kg gas canister lasts. For transportation we asked how many and what kind of vehicles were owned by house members, including MPV/SUV, Cars and Motorcycles. We then asked about the monthly fuel bill for each of these vehicles, only recording those with which the respondent was familiar. The electric power bill was asked about, along with the prevalence of air-conditioning usage. There were two questions relating to water bill and waste water bill, and one asking if the respondent was aware of if the dwelling was insulated. Finally, we confirmed what city the respondent lived in. In some cases the respondent gave additional pertinent information, such as the fact that cooking gas usage was exceptionally low because of the use of electrical cooking appliances, or abnormally high motorcycle fuel consumption related with the high engine capacity of the motorcycle in question.

7.1 HOUSING

There was good distribution of respondents in the various building types, reflecting a mixture of high medium and lower density housing. 63% of respondents lived in standalone houses, 18% in row houses, semi-detached houses and shop lots, and 19% in flats or apartments. Dwellings had on average 5 occupants with the lowest housing only one, and the maximum housing 12 people.

7.2 COOKING GAS

The rate of consumption of cooking gas varied widely, and was related with both house population and life style. Single occupant dwellings and houses where everyone worked tended to eat out most often, with a single 12kg cooking gas tank lasting well over a year in some cases, while higher density dwellings might consume a full tank in as little as two weeks. Typical consumption was about 0.9 kg/pax/month, about half of that estimated in our earlier household model. Only a few of the households used electrically powered stoves, and these residences showed a higher than average electrical power consumption.

7.3 VEHICLES

Passenger cars made up about 54% of the personal use vehicles, while 34% were motorcycles and 12% of the personal transports were MPV/SUV class vehicles. Passenger cars on average consumed about 240RM per vehicle each month, while SUV/MPV class consumed about 287RM and motorcycles consumed about 63RM per month. Lumping cars and MPV/SUV's together, and taking the emissions to be proportional to fuel consumption (per vehicle) times the number of vehicles, personal cars and SUV/MPVs are responsible for 90% of private road transport emissions, while motorcycles contribute 10%. This is in agreement with the breakdown of emissions for motorcycles compared to cars as presented in a previous detailed study (Gitano 2016). This is related with the larger, more powerful engines in cars and MPV/SUVs as well as how many kilometers they are driven.

7.4 ELECTRICAL POWER

One of the most important results came from the analysis of electrical power. Electrical power consumption was quite high in some residences with 16% of the respondents reporting a monthly bill greater than 400RM. Air conditioning usage was identified as the biggest contributor. The average electrical bill was 220RM, or about 50RM per person per month. Most dwellings had multiple AC units, with an average of 2 per dwelling. There was a strong correlation between the number of AC units, and the electrical bill. The typical "no air-con" bill was about 63RM, with an additional 77RM per month for each AC units. For the typical household (2 air-conditioning units) that would be a base line bill of 63RM plus 154RM for air conditioning (Figure 31). This means that urban Malaysian's are spending about 71% of their electrical power on air conditioning alone.

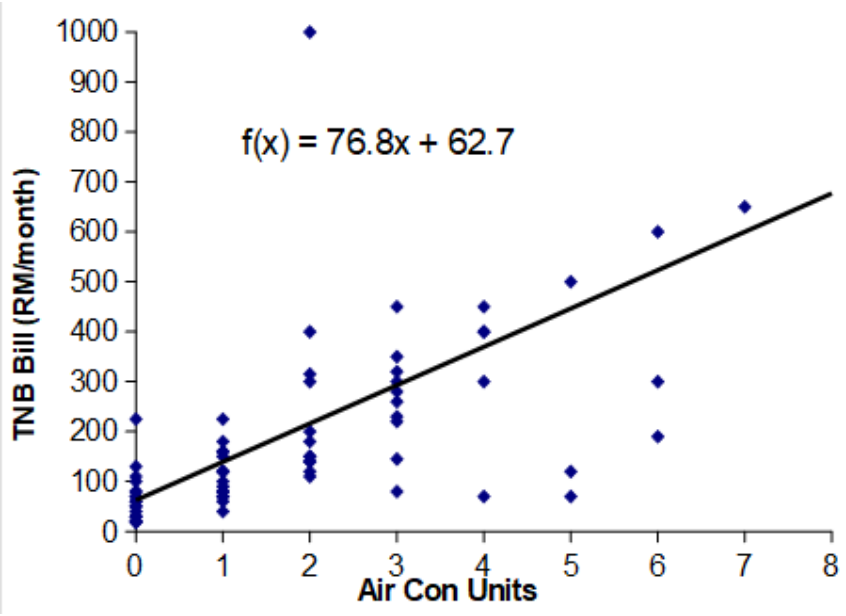


Figure 31 Survey Results of Electric Bill vs number of Air Con units

As consumers are spending such a large fraction of their electrical energy bill on cooling, and thermally efficient design is so rare in Malaysia, this is very clearly an important area for intervention.

In Malaysia, the mixture of primary sources of power is beyond the control of city administrations. However, with the introduction of the "my Green+" program by Tenaga Nasional, the national power company, individual power users can subscribe to a scheme where they pay an extra 8 sen/kWh in order to source power from "green" sources such as solar farms (TNB 2020). This program can collectively drive power providers to switch to cleaner power sources. While subscription to the program is on an individual consumer basis, cities could take on more of a role in promoting this among their constituents to improve their overall carbon footprint, as well as verifying that the extra power expenditures actually go towards sourcing "green" energy.

7.5 ANECDOTAL EVIDENCE

While performing the surveys many respondents proved to be very interested in the subject, and some of them had additional information and opinions. Interestingly very few of the respondents knew anything about whether their house or apartment actually had any insulation in the roof or walls. This was all the more surprising as many of the respondents mentioned that the house is often very hot due to solar heating, especially in the upper floors of 2-story dwellings. Many cited this as the reason for the prevalence of air-conditioning and excessively high electrical bills. Of those who knew about their house's insulation most of them (84%) admitted they were completely uninsulated.

Another surprising result was the significantly higher fuel bills associated with MPV/SUV class vehicles. Owners complained about how much they were spending on fuel, but did not express intention to move to a more efficient vehicle. This again underscores the need for intervention to

overcome the inherent weaknesses in human nature.

8. FUEL STATION SURVEY RESULTS

In addition to the household surveys, we visited several petrol stations to survey the annual mileage of various vehicles. Cars (including MPVs and SUVs) were driven on average about 18,000 km per year, slightly higher than the estimate in our house hold model. The lowest mileage vehicles only accumulated about 2,000 km per year, while a long distance commuter accumulated 38,000km per year. Government and corporate vehicles accumulated about 23,000km per year, very close to the Puspakom number for these cars (Gitano 2016). The average annual motorcycle range was about 8,500km per year, slightly higher than in our household estimate of 5,000km per motorcycle.

Taking the vehicle mileage numbers used in the household model (9.5 km/liter for cars, 45km/liter for motorcycles) we can calculate a typical fuel cost per vehicle for comparison to the above. Using the survey annual vehicle range, and the assumed mileages we would get a monthly fuel bill of about 350RM per cars, and 35RM per motorcycles. Despite this simplistic model and assumptions, the relative magnitude of car and motorcycle consumption are fairly similar to the household survey above (252RM for car/SUVs and 63 for motorcycles). Differences, of course, will arise from the actual vehicle mileage, as well as monthly mileage accrued.

9. CITY INTERVIEWS

The major portion of this study was devoted to the collection of feedback directly from the city administrators. We wanted to know what their impression was of the major sources of GHG emissions, what tools they used to analyze this, and what they could do to limit emissions. Most importantly we wanted to establish what were the biggest barriers they faced to measuring and controlling green house gas emissions at the city level. Generally, the interviews consisted of the author sitting down with various city officials, usually those involved in the Low Carbon City Framework (or similar) task force. Over a few hours we would discuss the various emissions related projects being undertaken by the city, and finally request follow on data for further analysis. A detailed list of the questions and data requested is presented in Appendix 1.

This section details the feedback received from the city administrators acquired during our interviews. The cities were quite enthusiastic about discussing their challenges, and were extremely receptive to receiving additional help in dealing with the problems facing them. Many of them have a number of carbon control projects in various states of implementation, but overwhelmingly they stated that they did not have the proper tools, training or dedicated manpower to assess green house gas emissions, and were in general unsure of the impact of the various projects on GHG emissions.

Many of the views were echoed by several of the cities, in which case they are presented in the “Common Responses” heading. Feedback unique to a given administration is listed under their heading.

Of special note is the fact that none of the cities were able to furnish us with all the data we requested. Cities with mature carbon reduction plans (for example Shah Alam, Petaling Jaya, Johor Iskandar, Melaka, and Sepang) were able to provide some overall city level statistics, but even then they admitted that many of the numbers were “top down” coming from population-based fractions of national numbers, rather than actual “ground up” measurements taken from the city itself.

9.1 COMMON RESPONSES

In general there was good awareness about the importance of green house gas emissions and control. All are aware of the “top down” direction to reduce GHG emissions (ie. to reduce carbon emission intensity by 45% per GDP per capita by the year of 2030), and work with the Low Carbon Cities Framework. All of the cities were concerned with reducing their carbon footprint, but generally had difficulty in prioritizing resources among various proposed projects. The most common feedback from the city administrators was:

- The primary source CO_2 data generally does not exist
- Gathering primary source CO_2 data from field measurements is tedious and beyond the capabilities of the administration
- Getting existing data from other government bodies is often difficult, slow, or impossible
- Analysis of the primary data (relating to CO_2 emissions) is beyond the capabilities of the current staff
- Often different departments within the same city administration have different levels of awareness and dedication to CO_2 reductions: some are very conscious and involved, while other departments are less concerned
- Illegal dumping was cited as a significant problem in a number of the cities. Some of them have nearly 100 known illegal dump sites, and are attempting to resort to CCTV surveillance to catch the vehicles/individuals involved.
- KPI Chasing: Higher level city administrators may be more interested in pursuing objectives which will provide publicity for the city, where as actual carbon reduction projects may hold lower priority.

Clearly the cities are having a hard time getting the basic data and do not have the manpower, training or equipment to take the data and analyze the CO_2 impact of abatement projects accurately.

9.2 INDIVIDUAL CITY RESPONSES

Beyond the common responses most cities had a substantial amount of unique feedback. This was generally related with unique circumstances or challenges faced by the city, or special efforts or projects they were involved in. Below are the unique feedback items by city:

PENANG

- No dedicated CO_2 analysis/calculation system exists for Penang at the moment
- River contamination contributes an unknown amount of CO_2, and not under the city's preview, but are considered an important source to contend with
- Rivers: The city claims to have no way to determine where the contamination and trash in rivers come from
- The required amount of data is "overwhelming" and would have to come from multiple different departments
- Industry: City has no way of knowing what their CO_2 emissions are
- There is a desire to initiate a waste to power system, but the required funds are substantial and hard to get
- Penang would like to set up an anaerobic digester station for organic waste
- Solid Waste Disposal Site (Pulau Burung) has been instructed to set up a Materials Recovery Facility to increase the life span of the dump site, but this has not been done yet, and is not directly under the city's control
- Electronic appliance waste is a serious problem
- Discarded tires are a serious problem
- A contractor is responsible for recycling, but their volumes are unknown, and likely only recycle steel, aluminum, plastic and paper

PERAI

- Perai reported a rather high 45% recycling rate, as Perai has taken over direct responsibility for solid waste collection and recycling
- The contribution to solid waste emissions from trucks and landfills CO_2 still unknown
- Upon further investigation the local dump site (Pulau Burung) was determined to not be sequestering methane.

JOHOR BAHRU

- Johor Bahru is unique in that the city includes a major international land border with Singapore. This swamps their “down town” vehicle parking as people heading to Singapore often leave their vehicles parked on the streets of JB for hours or days. Additionally, trans-boundary traffic, mostly Singaporeans or Malaysians working in Singapore crossing the border, dominates their Sunday traffic flow.
- Mega projects (Ports, Industrial zones, and recent advent of large integrated development projects, especially on re-claimed land fronting the shore) can easily overload the existing transportation infrastructure
- There is a published a “Low Carbon Society” plan for all of Johor, detailing many admirable action plans.

FOREST CITY MEGAPROJECT

Malaysia has long had a fascination with large development projects (for example Putra Jaya), but now there are an increasing number of “mega” land developments including both residential and more purely industrial projects cropping up. The east cost Malaysia-China Kuantan Industrial Park (MCKIP) is, as the name implies, primarily industrial.

Johor Bahru will be the host of the large Forest City mixed development project which, according to Datuk Md Othman Yusof, will contain a population of 700,000. This sizable community will be connected to Johor via 3 bridges (above image), exacerbating existing traffic and parking problems on already crowded urban streets. (Times, 2015)

JOHOR BAHRU TENGAH (ISAKNDAR PUTRA)

- There is great emphasis on public education and awareness building relating to environmental issues

- Too many federal/external organizations control processes which need to be changed in order to improve CO_2 emissions. For example to implement a “waste to energy” program the city would have to encroach upon SW Corp to get access to the refuse, and TNB to generate power. (Similar to the problem in Penang)
- Uncontrolled dumping of solid waste is a serious problem which is difficult to solve
- Traffic, especially 2-hour long rush hour traffic jams, are a big, trans-boundary problem
- GDP is not available at local levels
- The building department is not actively perusing building efficiency improvements and or CO_2 emissions reductions
- There is a lack of uniformity in rules: the new “Forrest City” mega development is allowed to perform its own electrical distribution (independent of TNB), where as JBIP is not allowed to do the same
- River waste is a trans-boundary problem, but there is close coordination on this between JB and JBIP, and are very actively working on this

PETALING JAYA

- Petaling Jaya is almost completely developed, thus is focusing on “infill” and “brown field” development, especially mixed-use
- PJ is working closely with SEDA (Sustainable Energy Development Authority) on building efficiency
- Electrical power and Transportation are clearly the major contributors to CO_2 emissions
- Changing the behavior patterns of consumers is one of the biggest challenges
- The city government has relatively little power to control the choices of consumers
- Individual consumers are reluctant to spend more initially on products or services which deliver better efficiency, even if it would cost them less in the long run
- Food waste is a big problem as “food abundance” is such an ingrained cultural feature

IPOH

- There is a lack of knowledge in how to evaluate a project and it’s cost/benefit ratio
- There is a great need to develop an integrated master plan covering all departments
- Ipoh needs greater buy-in and direction from the state and mayoral level

MELAKA

- The biggest problem is clearly traffic. This is exacerbated by the small roads surrounding the old town center.
- Plans to improve the traffic flow around the old town center, including the encouragement of small electric scooters and implementation of bicycle paths, has been overruled by federal road and safety department.
- Similarly plans to replace street lighting with more efficient LED lights has met with objections from JKR as the lumens (light power) of the lamps is not the same as the original lamps, thus JKR will neither install them, nor maintain them, pushing the burden to the city. This is clearly a point where better inter-departmental cooperation is required.

SHAH ALAM

- Federal level general direction needs to be backed up with sector specific goals, and the cities need to be given the required resources and authority to achieve these goals.
- Shah Alam was laid out for automotive traffic with large roads and roundabouts. This makes the overall city plan less amenable to non-motorized transport.
- Public transport is a federal commitment, but implementation is performed at the local level. Local level initiatives, such as free bus service, has been increasing the public transport ridership, and the system is being expanded, but where should the funds for expansion come from?
- Many programs "fail to thrive" due to a lack of integration with people's life style (eg. recycling programs that only accept recyclables during office hours, when the people who would recycle are unavailable due to work, Bicycle paths which are underutilized as there is no where to park bicycles safely at bus stops, and no showers at work). In order to achieve the maximum success any project needs to be integrated into people's life style, and may require "iterations" or adjustments from the initial idea to thrive.
- The CO_2 impact of "Green Belts" is especially difficult to accurately quantify.

THE MISSING LINK: BUSES IN LANGKAWI

The 2,000 taxis of Langkawi are driven on average about 5,000km per month. This results in approximately 6,000 liters of fuel consumption and 13.8 tons of CO_2 per taxi per year. Buses consume more fuel than a given taxi, but can carry many more passengers. Moving half of the taxi traffic to buses would result in an emissions reduction of over 10,000 tons of CO_2 per year and save consumers almost 100M RM per year[22].

LANGKAWI

- Public buses are urgently needed, but attempts to implement have been opposed by taxis and car rental businesses, which formed a picket brigade protesting the progressive project to protect their own enterprises

[22] 5000km/month x 12month/year / 10km/liter = 6,000 liters

- Training and tools are desperately needed as a comprehensive analysis of the full range of CO_2 control projects is beyond the capability of existing city staff
- Often times a city's projects wind up in conflict with federal or state regulations or direction, thus there is an urgent need to "unify" the approach build a cooperative approach to CO_2 reductions between federal, state and local governments
- Many different bodies are separately involved in various emissions control aspects or projects, but there is a lack of integration making it difficult to prioritize actions
- Traffic control is a unique and difficult problem for Langkawi as it is dominated by intermittent influx of tourists

SEPANG

- Often times the overall direction from above is very broad, thus hard to interpret at the implementation level
- Retrofitting efficient transport systems (eg. Bike, BRT or MRT lines) into existing neighbourhoods can be quite difficult.

9.3 INNOVATIVE CITY ACTIONS

Apart from identifying barriers and obstacles to sustainability, we also elicited feedback relating to innovative practices being pursued by the cities. The end result was a rather long list of environmental, efficiency and sustainability actions being undertaken by the various cities. Most of the actions are common to almost all cities, listed below under "Common Actions", however there were a few unique activities highlighted to us during the interviews which could be of benefit to other municipalities. These are listed below under the various city's names. A link to the individual cities carbon reduction plan can be found in Appendix 4 as available.

COMMON ACTIONS

The following actions were the most common among the various cities carbon control plans, and a good guideline for urban CO_2 reduction:

Promotion of "Walkability" of Urban Centers
- Covered Pedestrian Walkways
- Pedestrian Through-Ways crossing large development projects
- Connectivity of Pedestrian Paths to Public Transport
- Provide Safe Walking/Bike Routs to Schools
- Traffic Calming (eg. Raised Pedestrian Crossings at Roads)

Bicycle Path Implementation or Expansion

Integrated Community Centers (Library, Clinic, Hawkers, etc.)

Urban Green Space Promotion
- Urban Parks Integration with Bike/Ped Paths
- Tree Planting

6000liters x 2.3kgCO_2/liter = 13,800kg CO_2
1000 taxis x 13.8ton CO_2 = 13,800ton CO_2 per year
Typical fare is 30RM/20km: 1000 taxi x 5,000km/month x 12months x 30rm/20km = 90M RM per year

- Urban Farming/Composting
- Waterway Trash Cleanup
- Anti-Littering Campaign
- Urban Drainage Flood Abatement, Settling/Drainage Ponds, Integration to Parks
- Solid Waste Reductions and Improvements
  - Emphasize Recycling, Reduction of Consumption and Reuse
  - Implement 3-Bin System Everywhere
  - Implement Waist Separation Facility/Materials Recycling Facility
  - Waste to Energy Study/Pilot Project
  - Composting at Home/Community
  - E-Waste Collection/Recycling
  - Landfill Methane Capture
  - Construction Waste Management
- Sustainable Sewerage Planning
  - Improve Quality of Waste Water Effluent
  - Sludge Recycling
- Encourage Efficient Water Usage
  - Low-Flow Public Toilets
  - Grey/rain Water Capture/Use
- Plan and Capitalize on Developments near Transportation Hubs (TOD)
- Encourage Public Transportation Ridership
  - More/Better Routs
  - More Frequent/Timelier Busses/Trains
  - Free Busses
  - Better Bus Stops (Lighting, Rain Cover, CCTV)
  - Connect to Bike Routs, Provide Bike Parking
  - Real time Public Transportation Information Displays
  - Simplified Ticketing (Flat Rate, Touch and Go…)
  - Better Inter-Modal Connectivity (Bus – Train etc.)
  - “Park and Ride” Lots in Suburbs
  - Increased Parking Fees in City
- Encourage Car Sharing, Car Pooling and Car Free Day
- Implement Smart Traffic Management Systems to Improve Traffic Flow
  - Transportation Demand Management
  - Traffic Light Optimization, move to LED lights
  - Stagger Working Hours to avoid Rush Hour Jams
  - “Anti Idling” Campaign
- Promote Electric Vehicles/Low Emissions Vehicles
  - More EV Charging Stations
  - Procure EVs /Hybrid for Municipality, Public Transport
- Green Building Promotion
  - Conduct Energy Audits
  - Set Air conditioning to 24°C
  - Upgrade Existing Buildings
    - Procure more Energy Efficient Appliances
    - Change out Filament Bulbs for LEDs
    - Impose Additional Greenery on Buildings and Plots
  - Implement Energy Management Systems
  - Real-Time Information Systems related to Energy Use and Control

- Mixed Use Development
- Increase Solar Photovoltaic Capacity (eg. on Roofs)
- Encourage “Passive” Designs
- “Green” Materials Promotion
- Enforce adoption of MS1525
- Impose Low-Carbon Certification of Buildings

Community Outreach

- Adopt a Park/Tree
- Community Gardens
- Recycling Events
- Low-Carbon Awards
- Public Awareness/Education Programs
- Promote “Eco Tourism”
- Promote “Work From Home”
- Encourage Renting/Borrowing instead of Buying

Governance

- Set Clear, Achievable Carbon Targets
- Monitor and Publish Pertinent Environmental/GHG Data
- Design Zoning for Best Urban Sustainability
- Preserve Green Spaces within City
- Reward Low-Carbon Projects
- Streamline Planning Approval Processes
- Develop Human Capital for Low-Carbon Governance Enactment
- Partner with DOE/SW Corp/Other organizations in fulfilling the above

PENANG

Penang is planning on improving the pedestrian friendliness of its historic Georgetown district, including converting some of the existing roads to pedestrian only traffic. Additionally, there are major expansions of its bicycle lane network including a beach front combines pedestrian and bicycle path (Mok 2019).

PERAI

Perai has taken over responsibility for the collection and separation of trash from SW Corp. Due to their acute focus on this area they claim to have achieved a 45% recycling rate of discarded plastics.

PETALING JAYA

Petaling Jaya has implemented an innovative “Environmentally Friendly” assessment tax rebate of 20% for various home efficiency improvements. Among other things this also encourages rain water harvesting to alleviate fresh water supply problems.

Rain water harvesting is also being emphasized for larger buildings; the SS2 wet market has 7,500 liter rain water catchment capacity installed.

PJ has also begun using anaerobic digesters converting food waste to cooking gas at various locations around the city.

JOHOR BAHRU

While many of the cities said they had trouble getting electrical power consumption data for given geographic locations from TNB, MBIP and MBJB both mentioned that they have been working closely with TNB to get “local” power consumption numbers. This is surly something the other municipalities will want to duplicate.

IPOH

Ipoh is unique in that the town center has been laid out on a grid pattern with very wide roads. Despite this there are several bottlenecks around the town center. They are planning on creating a pedestrian friendly old town center by closing down some of these streets, and turning them over to bicycle and pedestrian traffic.

Additionally, Ipoh is embarking on a city-wide tree planting program.

JOHOR BAHRU TENGAH (ISAKNDAR PUTRA)

While the Skudai river passes through Iskandar Puteri for just 6 km, MBIP has been pursuing an aggressive campaign of cleaning up the river, involving not just trash removal from the river (which removes 26 tons of trash per month), but going up-stream to the tributaries and tracking pollution to its source. This is being combined with a public awareness campaign to reduce river dumping. Additionally, MBJB and MBIP are closely coordinating efforts to keep the river clean in an excellent example of trans-boundary cooperation.

MELAKA

To encourage bicycling MBMB has been offering a stipend of 150RM per month for municipal office workers bike to work.

Similar to Penang and Ipoh, Melaka is planning on converting several of the streets in the historic old town section to pedestrian only traffic.

As a follow on to the clean up of the Melaka River, the tourist taxi boats will be converted from 2-stroke outboard motors to more efficient, cleaner 4-stroke engines.

SHAH ALAM

Shah Alam has been working on increasing ridership in public transport for a number of years. This includes implementation of the Selangor Intelligent Transportation System (SITS) on-line tracking system, as well as smart bus stops (incorporating such features as lights, rain cover, free WiFi, CCTV, and a “panic button”), free busses, bike sharing, e-scooter sharing and transportation hub integration. The SITS and smart bus stops specifically are efforts worthy of emulation.

LANGKAWI

Although Langkawi is just getting started with their carbon control and mitigation strategy, there are several unique projects under consideration including a short tram along the more popular

“beach strips” which become jammed and impassable with car traffic at high tourist times.

Additionally, Langakawi is interested in reducing the environmental impact of solid waste disposal which is perceived to be a potential threat to local water quality, and thus harboring a negative impact on tourism.

SEPANG

The SITS is also used in Sepang, allowing users to see exactly where the busses are on their routs, and how many minutes away they are from the local stop. This is an ideal system for areas where bus or other public transport run infrequently. Riders can check when the next bus will be coming, and get to the bus stop just in time, without having to wait long periods of time.

9.4 HIGHLIGHTED RESPONSES

The vast majority of the cities feedback related directly to the individual CO_2 reduction projects, however as some of the cities which have participated in CO_2 reduction programs had some very specific feedback, which was repeated by multiple cities.

Many of the administrators acknowledged that the administration is highly motivated by positive publicity, in fact it was said “*The mayor is more likely to provide funds for something that will give us good marketing value than something that may improve the CO_2 footprint, but remains ‘anonymous’*”.

9.5 SELECTED CITY ACTIONS COMPARISON GUIDE

While each city may be considering a wide range of specific actions (as many as 60 in some cases), Figure 32 is a table of a few selected actions showing which cities have published actions addressing these areas. Note that this is just a table of *published* plans, which do not necessarily indicate actual success of the given actions. For example, Sepang has a very complete set of plans for transportation including actions targeting increased public transportation and bicycling, however the current rate of public transportation usages is only approximately 7% in Cyberjaya. Bicycle use has been emphasized in previous low-carbon city plans, targeting 20% bicycle user rate by 2020, however the actual bicycle usage for commuting to work is very low: Even though Melaka offers a monthly stipend to employees commuting by bicycle only one person had taken it up as of 2019[23].

This serves to highlight the fact that one of the major flaws in many carbon reduction plans is that they rely heavily on potentially dubious estimates of future effect. One of the keys stressed in CO_2 reductions is the need to evaluate programs based on *actual results*. This requires a baseline measurement at or before the beginning of the project, followed up with comparison data taken once the project has been implemented. Only in this way can the true effects of a given project be

[23] From interview with Melaka city government, 29 August 2019

assessed. Additionally, follow up is almost always required to provide feedback and adjustments to the project for best results. For example, Shah Alam implemented an aggressive recycling program with several recycling centers. It was later found to be seriously underutilized in part because the recycling centers hours were typical office hours, when the potential "customers" were mostly at work. Adjusting the centers operating hours made for an increase in recycling[24].

Looking at the table in Figure 32 we can easily identify a few categories which are relatively under represented in the cities plans. In transportation the two most notable gaps are in light rail transit and an on-line, real-time public transportation location/schedule system. Light rail systems are very expensive to develop, and require many years of planning, and consistent support from the government. For example, the 37 km LRT3 expansion was projected to cost 16.6 Billion RM, and require 6 years to complete (The Star 2018) however public transport information systems, such as the Selangor Intelligent Transit System, are relatively inexpensive, and can be implemented quickly.

While all municipalities have some kind of recycling program, relatively few had any specific programs on river clean up beyond the removal of surface trash, or programs on composting of urban food and garden waste which still constitutes about 45% of municipal solid waste.

Finally none of the municipalities had any projects directed to sequestration of landfill methane. This glaring deficit is largely due to the fact that the responsibility for the land fills lies with SW Corp, and not the cities. Again, this highlights a fundamental flaw in many carbon footprint assessments: effecting a change depends not on the plans of a single governmental body (eg. a city administration), but on the overall implementation with participation from many different organizations and individuals. Emissions problems are multidisciplinary by nature, requiring a holistic approach. Solid waste has been highlighted as one of the major contributors to green house gas emissions, and cities are responding with a wide range of strategies, including recycling, reuse and reduction of disposables. While these are all very important and will go a long way towards reducing our environmental impact, emissions from existing land fills remains unaddressed. Landfill methane is a major contributor to GHG emissions, however it is beyond the control of the cities.

[24] From interview with Shah Alam city government, 30 August 2019

ACTION CITY:	I	IP	JB	L	M	PJ	PP	S	SA	SP
Sustainable Urban Development Plan		Y	Y	N	N			Y	Y	
Increasing Mixed use Development		Y	Y	N	N			Y	Y	
Integration of Public Transport System		Y	Y	N	N	Y		Y	Y	
Online Public Transportation System	N	N	N	N	N	Y	N	Y	Y	N
Light Rail Transportation	N	N	N	N	N	Y	N	Y	Y	N
Bus/BRT Public Transportation	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Electric Vehicle Promotion	N	Y	Y	Y	N	Y		Y	Y	
Encouragement of Bicycling	Y	Y	Y		Y	Y		Y	Y	
Improving Walkability	Y	Y	Y	Y	Y	Y		Y	Y	
Building Energy Audits	N	N	N					Y	Y	
Encourage Building Retrofits for Efficiency	N	Y	Y			Y		Y	Y	
Solar/Alternative Energy Production	N	Y	Y					Y	N	
Community Engagement		Y	Y			Y		Y	Y	
Recycling	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Green space promotion	Y	Y	Y					Y	Y	Y
Active River Cleanup Program	N	Y	Y	N	Y	Y	N	Y	N	N
Waste Water Sustainability	N	N	N					Y	N	
Composting – Organic Waste Separation	N	Y	Y	N	N	Y	N	Y	Y	N
Methane Sequestration at Landfill	N	N	N	N	N	N	N	N	N	N

CITY ABBREVIATIONS: I = Ipoh, IP = Iskandar Puteri, JB = Johor Bahru, L = Langkawi, M = Melaka, PJ = Petaling Jaya, PP = Penang, S = Sepang, SA = Shah Alam, SP = Perai

Figure 32 Selected actions as published by the various cities. Yellow indicates that the data was not available.

10. OBSERVATIONS AND "GAPS"

In this study we collected information from various international, federal and state levels, as well as extensive face-to-face interviews with the various municipalities, and government bodies. Additionally, we performed on-site observations, data collection and surveys. We arrived at a wide range of observations and conclusions relating directly with the measurement and control of CO_2 at the city level. These observations are enumerated here, while recommendations for further action are explained in detail in the subsequent section.

10.1 RED TAPE

In Malaysia, governmental authority is highly centralized, requiring direct intervention from the highest levels before anything can happen. Additionally, Malaysian governmental etiquette requires a rather lengthily protocol of meetings, often including the exchange of "letters of introduction", before anything can happen. Essentially it may require up to four separate meetings before the appropriate parties can sit down and actually discuss data. The scenario unfolds something like this:

FIRST MEETING
In this you explain the purpose of the study or visit to whoever in the designated organization you were able to get an audience with. If this is successful, they pass you on to someone in the relevant department.

SECOND MEETING
Here you again explain the purpose of the study, and what data is needed, to the appropriate person who will then take it to the higher authority.

THIRD MEETING
In this third meeting you are actually talking with someone who has the authority to allow you to collect the required data from within his organization. This will require scheduling a fourth meeting with the individuals responsible for supplying the data.

FOURTH MEETING
Finally, you are face to face with the right people and have the permission to get access to the required data.

In some cases, such as with MESTECC, even getting the first meeting can take several months via exchanges of calls, emails and letters. Thus, one of the most striking early observations is that due to highly centralized decision making in Malaysian governmental organizations all decisions must be referred up to the highest-level authority within an organization, before making its way back down to the individuals involved in execution. While this may be a minor nuisance for a study like this, it is indicative of an inherent inefficiency in this type of organization. Information exchange is crucial for decision making, and thus information should be shared *freely* and *rapidly*.

When every decision has to be fed back to a central authority it inevitably slows down decision making within that organization. Greater delegation of responsibility, diffusion of authority, and empowering others within an organization to make decisions can greatly improve that organization's flexibility and speed of execution (Refaay).

Furthermore, the type of information which is being sought is not considered "classified", thus there are no good reasons for making access to it difficult. Rather than restricting access to the relevant data, it should be made "open access" allowing as many interested parties access as possible.

10.2 ORGANIZATIONAL ISOLATION

From first hand experience, as well as feedback from the city representatives, a significant amount of isolation between various governmental organizations was noted. For example, the state of Penang is covered by two municipalities, MBPP and MBSP, which basically covers 100% of the state. The Penang Water Authority (Perbadanan Bekalan Air, PBA) covers the whole state, but apparently does not directly share data with the two municipalities even though they make up 100% of its customer base. Similarly, several cities complained that it is difficult or impossible to get geographically refined electricity consumption numbers from the federal power company TNB, while other cities managed to get access to just such refined data. Even within a given city administration, different departments may not share information and planning related to CO_2 controls. This "isolation" of crucial data within independent organizations will impede progress in terms of emissions control and planning, much of which requires inter-departmental cooperation. Some of the relevant organizations actually have the data at the finer geographic resolutions required for CO_2 mediation policy, and these should be freely shared with all interested parties. If municipalities continue to have difficulties accessing crucial data, a federal mandate to make the data freely available may be required.

10.3 DISPARATE COMMITMENT AT CITY DEPARTMENTAL LEVEL

Even within city governments there can be widely varying levels of commitment to common goals. Although allegedly the entire municipal government is invested in the nationally stated low-carbon targets, in several cities it was noticed that while some departments were clearly aware of their individual goals and actively involved in achieving them, others were either unaware of the importance, or simply much less committed to the common goal. For example, in one city the transportation department was very aware and active in CO_2 emissions reduction, however the building department was much less interested in pursuing the same from its end. Several city representatives stated that they want strong direction from the top (ie. the federal, state and mayor) driven down to the individual department level to help clarify emissions goals and unite efforts towards GHG reduction.

10.4 CO_2 DATA AVAILABILITY

The most common feedback from the cities was that the primary data relating to CO_2 emissions was difficult to get. Some of the factors, such as electrical power consumption, exists but not at the fine geographic scale (ie. individual neighborhoods) required for detailed analysis. Other times, such as in the case of traffic flow, the data may only be available for certain roads or intersections. It may also be the case that the data simply does not exist, for example the organic contamination levels of main rivers is monitored, but the individual tributaries are not tracked, making it difficult to trace down the source of the problem and rectify it. Much of the data is "owned" by different organizations, eg. Indah Water Konsortium exclusively has information relating to the sewage water quality and quantity, TNB has electric power, and generally only the DOE has surface water quality numbers, making it time consuming to compile all the data required at a city level. A national level mandate requiring data availability and national emissions data base do not currently exist.

10.5 CO_2 DATA ANALYSIS

Even when data exists, analyzing it to yield equivalent CO_2 emissions is difficult, and the calculations are often beyond the capacity of the city personnel. This is especially true in the case of trying to evaluate the potential CO_2 gains from a given project. If, for example, a city is contemplating putting in a green belt with a walk/bike way and shade trees, there will be a CO_2 impact from the micro climate created by the shading and hydro-logical cycle of the trees, shading effects on surrounding buildings and roads, CO_2 sequestration in the biomass of the green belt, and potentially a reduction of motorized traffic as a result of increased pedestrian and bicycle traffic. Calculating the CO_2 impact of these various factors requires expert analysis, which currently does not exist uniformly at the city level. The lack of knowledge of CO_2 impact makes it very difficult for cities to prioritize potential remediation projects. Additionally, even when analysis tools do exist, as in the case of the various "green building" evaluation tools (of which there are many), they can be extremely detailed and tedious to use, and in the end the results are often dubious or even out right misleading. Studies have shown, for example, that in some instances that LEEDS certified "green buildings" actually consume significantly more energy per area than non-certified buildings of similar size and location (Owen 2009).

10.6 JURISDICTIONAL ISSUES

In many cases the cities have attempted to implement a CO_2 remediation program, but lacked the authority to do so. Several times cities stated a desire to implement a waste-to-power program, but mentioned that the authority for electrical power generation is currently monopolized by TNB, and that, in some cases, Solid Waste Corp. "owns" the garbage in question. Lacking the authority over these materials or processes the cities are unable to implement their desired remediation strategies. A notable case of this is solid waste. Many of the municipalities are aware of the impact of methane sequestration at land fills, but lack the power to implement this as it is the

exclusive preview of SW Corp.

10.7 TRANS-BOUNDARY ISSUES

Many of the cities are faced with trying to control the emissions from some form of trans-boundary flow or source. Rivers, surface traffic and solid waste are common sources of emissions which are not uniquely contained within an individual municipality. In cases like these the control over the related emissions is clearly out of the hands of the individual city working in isolation on the problem.

10.8 INDUSTRY

Industries can be a major contributor to GHG emissions, and many cities contain a wide range of different industrial producers. Beyond actual energy usage there are several industries known to generate large amounts of green house gasses including: cement manufacturing, metals smelting and processing, palm and paper mills, and various industries using high GHG potential gasses. While the heavy industries tend to be located outside city boundaries, many of these emitters can be found within industrial sections of cities. Often the cities know very little about the individual processes and effluents of the industries operating within their boundaries. Lacking this information, as well as the expertise of analyzing the GHG impact thereof, excludes the municipalities from having any meaningful control over industrial emissions.

10.9 RECYCLABLES

The various cities have different ways of dealing with recycling. All are involved in some kind of public awareness, and recycling program, however, the actual process of recycling is sometimes performed by the municipality, and at other times is delegated to a concessionaire or sub contracted out. Generally, recycling of industrial debris is left up to the individual industries. Commonly recycled materials include ferrous metals, aluminum, paper and sometimes plastics. Often other recyclable materials, including glass and organic debris (food and garden waste) are simply land filled[25]. Finally, some recyclable materials, notably used tires and electronic waste, often become a problem for the cities as they are unaware of how to dispose of them[26].

[25] From interview with Petaling Jaya, 6 August 2019

[26] From interview with Penang Urban Services Department, 14 August 2019

10.10 ILLEGAL DUMPING

Many cities complained of uncontrolled, illegal dumping, a growing problem in Malaysia (Straits Times 2019, The Star 2019-2). While they are mostly concerned about the dumping of solid waste recent events at Pasir Gudang highlight the issue of illegal dumping of chemical and liquid waste as well. Illegal or uncontrolled disposal of gaseous compounds is likewise a problem of unknown magnitude[27].

10.11 LIMITED CONTROL OVER CONSUMER CHOICES

City administrators are in general very aware of the impact of consumer choices on emissions. For example, it is universally understood that taking public transport generates much less CO_2 than driving a personal SUV to work each day, however the city lacks direct control over the user's choice of vehicle, or even how they choose to commute, where they live and where they work. This extends to other product and resource consumption as well.

10.12 ENFORCEMENT

In some cases, such as with national building codes, an appropriate set of regulations exists (eg. MS1525), however it is not uniformly applied. The example of building thermal insulation suffices to demonstrate the existing problem. In some cases this is due to a lack of knowledge of the regulation, lack of tools or even manpower to perform on-site inspections. Additionally, many of the existing standards are fairly elaborate and may be difficult to interpret. A simplified guideline and training program for local inspectors would go a long way to resolving this problem.

10.13 DETAILED DIRECTION, RESOURCES AND AUTHORITY

If federal authorities can provide more detailed targets, broken down by sector or even department, it will make it much easier for cities to prioritize their work. Detailed guidelines for projects, incorporating best practices, case studies and analytical tools, will similarly reduce the burden on the cities. Additionally, implementation of many of the projects to achieve these goals will require resources, both financial and tools and expertise. A federal level carbon reduction financing scheme may be required to get the municipalities the funds required to implement some projects. Finally, in certain cases the cities may require authority to change select rules or regulations, or restrictions emplaced by other government bodies.

[27] From interviews with Iskandar Putra, 7 August 2019

11. RECOMMENDATIONS FOR ACTION

Many corrective actions follow directly from the “gaps” or obstacles identified in the previous section. Additionally, during the interviews city administrators often suggested courses of action which would help them overcome these gaps. From their input, and our own analysis of the survey data, we have come up with a series of recommendations for improving the ability of cities to combat carbon emissions, and improve the overall sustainability of municipalities. While the ultimate responsibility for resolving these issues lies with the Malaysian government, concerned NGOs may be able to provide some assistance in several areas, as noted below.

11.1 GENERAL ACTIONS

One of the clearest needs is for the cities to have a standard set of guide lines and tools for assessing and implementing carbon reduction projects. Overall environmental direction is provided by the federal government; however local authorities responsible for implementation often do not have the required knowledge or tools (Saleem 2005). Although a wide range of carbon assessment packages exist, this is still the number one problem mentioned by the cities. Many different tools exist, either for individual aspects of CO_2 emissions (eg. buildings), of for general application to built up areas, cities and etc. A few of the more common building assessment tools are:

BREEAM	Building Research Establishment Environ. Assess. Method (UK)
LEED	Leadership in Energy and Environmental Design (US)
Greenmark	Singapore
Greenstar	Australia
Green Building Index	Malaysia

However, many of the existing tools are overly complex, making them difficult to use. Ideally an expert from the DOE, MGTC or other organization, working with the cities could determine which package is the most appropriate and then develop a training course for municipal employees involved in carbon reduction. Best practices, guidelines and case studies from actual projects will greatly improve the cities ability to prioritize and effectively implement carbon reduction projects. Ongoing workshops could be held where the various cities' projects could be evaluated and analyzed for their CO_2 impact, sharing experience among the cities and helping them all improve their team’s abilities together on real-world applications. Additionally, members from the different city departments could be similarly trained helping to emphasize the importance of CO_2 reduction through out the city’s organization.

WHEN GREEN ISN'T GREEN

"Green" buildings don't necessarily save energy or money. One study showed that "green" certified buildings showed no savings over similar non-green buildings, and some categories actually under-performed equivalent conventional structures (Xie 2017). This can be caused by careless work by builders, overly complicated energy-saving technology, or the bad behaviors of the eventual occupants of a building and, more crucially, inept energy modeling in the design phase (Conniff 2017). Pursuit of a "green" certification, especially when motivated by "reputation enhancement" as opposed to actual savings, may sometimes override common sense. A good example of this is a new "showcase" corporate HQ in California USA: the building saves ~15% over the old HQ but people are forced to travel over twice as far to get to it, resulting in a total of ***50% INCREASE in emissions*** over the old building when including the employees commute!

ACTION 1

Develop a Training Team using standard tools and easily understood guidelines for CO_2 reduction project assessment. This should include real-world examples of common city level projects. Multi-departmental city "Carbon Reduction" teams should be trained in the tools and standard practices by the team.

Ideally the various city carbon teams would work together to overcome common obstacles. This would involve not only sharing best practices and experiences, but also extend to cooperation on trans-boundary issues. A further extension of this would be to form a *carbon implementers advisory group* which could highlight specific common problems to the federal authorities in order to achieve changes in federal or state policy, and enlist the aid of various associated federal bodies (eg. SWCorp, TNB, etc.). This body could more directly overcome the "isolation" between the cities and various state and federal bodies.

ACTION 2

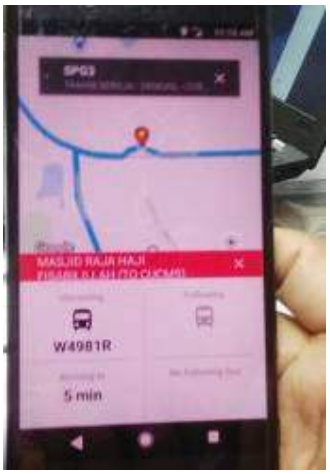
Develop a national level "association" of city carbon reduction teams for the sharing of experiences, tools and expertise. Collectively this association may be more effective at approaching state and federal level organizations in order to get more clearly defined goals, resources and authority. Additionally, this same group may be able to negotiate jurisdictional disputes with federal bodies more effectively.

Based on our assessment the three largest contributors to CO_2 emissions from the city are transportation, electrical power consumption and solid waste disposal. Therefore, we have separated out items specifically for these areas next.

11.2 TRANSPORTATION ACTIONS

Many sources, including our household model, indicate that transportation is one of the most CO_2 intensive activities. Malaysia is an exceptionally high emitter of transport related emissions for a number of reasons including the high rate of automobile ownership, low cost of fuel, and extensive automobile infrastructure. Evidence of this is readily available: while Malaysian highways are the envy of SE Asia, we also have daily traffic jams, even in smaller towns such as Parit Buntar, thanks to the prevalence of private car usage. Studies show that use of public transport can reduce emissions by about 50% compared to use of private cars (Gitano 2016). One obvious solution is to encourage the use of public transport, and discourage use of private transport, especially cars and MPV/SUVs, except when really necessary. Many efforts can be made to improve transportation efficiency, including implementation of vehicle fuel economy standards, progressive taxation of inefficient vehicles and a crack down on “smoke belching” trucks, however these are largely out of the cities' control. For example, the Department of Environment is responsible for enforcing the vehicle emissions standards. This does not leave them completely helpless however, if they can band together as mentioned in Action 2 to take collective action to push the federal government for stricter vehicle standards.

One of the simplest and most effective ways of increasing public transit ridership is to provide live information on the transport’s location. This is especially true in areas where there is a long wait between transports. If users know when to expect the bus or train, they can finish up their work, and make it to the transit stop in time to catch the transport without having to waste a lot of time waiting. Fortunately, Selangor has implemented just such a system, the Selangor Intelligent Transportation System (image at right), where users can view the transport location live, and an accurate expected time of arrival at their location. It is highly recommended that all public transport be connected to a nationwide system available to all (Gitano 2016).



ACTION 3

Implement a nationwide on-line public transportation system similar to the Selangor Intelligent Transportation System. This should cover all public transport including buses, trains and ferries.

While some CO_2 mitigation actions are amenable to calculation of the CO_2 impact (for example replacing conventional lamps with higher efficiency LED lights), others are much more difficult to estimate. Many transportation projects fall in this category. Individual passenger kilometer emissions can be determined for different transportation modes, but the more difficult analysis is to determine exactly how many passenger kilometers and in what modes are effected by a given transportation project. This is one area where it would be especially helpful to have a standard set of tools and training by experts as mentioned in Action 1 above. Additionally, the effectiveness of a given transportation project depends greatly on how it effects an overall commute. In some cases a well meaning project, such as the new bus terminal at Aman Jaya, Ipoh, can actually have a *negative* impact on emissions reduction. The iconic old train station in Ipoh is located

within easy walking distance of the center of town. The new Aman Jaya bus terminal is about 10 kilometers outside of town, and, as shown in the map in Figure 33, has a connecting bus to town only once an hour. This means that passengers arriving in Ipoh by bus may need up to two hours to get to the train station and the center of town. Clearly this will be an impediment to anyone seriously considering commuting to Ipoh by bus.

Figure 33 Aman Jaya bus terminal to Ipoh Train Station commute

A similar situation occurs in many other cities, for example Sibu Sarawak, where there is no public transport from the airport to town. In Langkawi the implementation of a public bus system was so vigorously opposed by local taxis and car rental companies, that the project was halted in 2014[28]. There are no buses or other public transport from the airport, ferry terminal or from the town center to any of the popular destinations at all. Transportation projects can not accurately be assessed in isolation, as they are generally part of a much larger picture and in general a given transportation hub is neither the point of origin or destination of a given trip, but an intermediate step. With this in mind it is very important that *all* transportation hubs and city centers are inter-connected via express public transit links.

ACTION 4

Public transportation hubs such as airports, train stations and bus terminals should be linked together, and to the city center via express links allowing commuters quick and easy access to the entire transportation network as well as to the major centers within the city. This includes all cities large enough to have an airport, ferry terminal or major train station.

Cities have relatively limited ability to control individual's choices in how they move about. Encouraging use of public transport, smaller vehicles, and non motorized transport can and

[28] From interview with city administration 12 September 2019.

should be done, however some times cities wind up in a situation where the vast majority of commuters chose to drive personal cars to and from work and shopping, creating traffic congestion. This greatly contributes to emissions as most cars only achieve their optimum fuel consumption (and emissions) at speeds above 50kph (Shahid 2014). It may therefore be necessary for some cities to take deliberate traffic congestion mitigation steps.

ACTION 5
Cities may have to take active steps to mitigate traffic congestion including such options as congestion charging, single occupant vehicle bans, and even converting urban center roads to pedestrian only zones.

11.3 ELECTRICAL POWER ACTIONS

Electricity is used for a wide range of applications, not all of which can be directly addressed by a cities' administration. Industrial applications are addressed in a separate section below. Utilization of the most efficient electrical appliances should be encouraged, but as with consumer choice in transportation, it is largely out of the control of the cities. As noted in the results of our survey a large percentage of the residential and commercial electric power in Malaysia is consumed by air conditioning. Fortunately this is an area where the city can have a fairly major impact. Building efficiency can be addressed via two different channels: new building construction standards, and retrofits for existing buildings. Non-residential building construction standards are covered under the Malaysian Standard MS1525, however this is not an easily interpreted guideline for building inspection. What cities need is a simple guideline for building construction and inspection in order to confirm that the building is built to a reasonable level of thermal efficiency. In some cases, a new standard may have to be developed, and published so that building planners are aware of the expectations prior to designing the building.

Generally, the aspects of building thermal efficiency are well understood and include the following:

- Light colored external surfaces (especially roofs) to reflect solar radiation
- Roof insulation consisting of a reflective barrier (typically a aluminized paper or plastic coating) plus a layer of fiberglass (rock wool) or Polyurethane foam insulation
- Ventilation of the ceiling-roof space to remove heat
- East-West orientation of buildings to present the smallest side area to solar influx
- Large roof overhangs to prevent direct solar heating of walls and windows
- Tinted and double pained windows
- Awnings or external grills preventing direct solar ingress while allowing in diffused lighting
- Building landscaping incorporating close-in trees to help shadow building
- Use of insulating materials on sunlit external surfaces

While much of this is delegated to national building codes, it is not being applied to residences. Given the amount of energy consumed by air conditioning in Malaysia, it is very important that cities take a more active role in ensuring that buildings within their jurisdiction are as efficient as possible. Many of the household survey respondents mentioned that they are spending a very significant amount of money (an average of over 150 RM per household each month) on air conditioning, and with out AC the house is very hot. Neglecting to insist on efficient buildings is costing consumers a lot of money, and creating vast quantities of emissions unnecessarily. Roof

insulation is probably the single best cost/benefit investment that can be made as 75% of the solar heat ingress to a single-story house comes in through the roof: CO_2 emissions can be significantly reduced and consumers will save money in a very short time (Von 2009).

ACTION 6
Develop a simple set of guidelines for new building construction and inspection to insure that all new construction conforms to a reasonable level of thermal efficiency. This should be provided to all new development projects, and developed into a national standard applied to all inhabited buildings, including residential buildings.

Although it is more difficult to implement some of these energy efficiency measures on existing buildings than new constructions, given the amount of energy being wasted on cooling of inefficient buildings it is also important to apply as many of these techniques as possible to existing buildings. Petaling Jaya gives assessment tax rebates to buildings that apply energy saving measures, including such things as insulation and on-site rain water storage. One of the difficulties, as highlighted by several of the cities, is that end consumers are rather short-sighted financially, thus they have a difficult time rationalizing a near term expenditure, for example buying insulation or a roof ventilation fan, in order to gain a long-term return on investment. Thus building greater public awareness of the importance of building efficiency in general, and thermal insulation in particular, should be a major priority.

ACTION 7
Develop a building energy efficiency retrofit public training program emphasizing the cost/benefit of various common building improvements in order to encourage consumers to implement energy and money saving measures. Ideally this would also include local teams who could help individual home and business owners' assess their buildings, and work with them through the project, collecting data in order to improve their techniques and publicize the savings to be realized.

11.4 SOLID WASTE DISPOSAL ACTIONS

From our initial household assessment solid waste emissions were determined to be the third largest category of emissions. The fundamentals of waste emissions reductions are basically Reuse, Reduce and Recycle, and all of the cities were very aware of the need to recycle, and actively involved in public education programs to this end. In some cases, such as Perai, the municipal government has taken over trash collection and separation in order to increase the rate of recycling. Perai has also embarked on an "Eight R" recycling public education program, including Rethink, Refuse, Reduce, Reuse, Repair, Re-gift, Recover and Recycle (FN 2019). There are, however a few areas which are either out of the control of the cities, or require special attention.

First and foremost is the actual landfill. As mentioned earlier, landfills without methane sequestration can emit more than five times the emissions of sequestered methane landfills. No matter how diligent a given city is in the three (or eight) "R's" of recycling, if the waste is going to a

methane out gassing landfill, they are contributing vast quantities of green house gasses.

ACTION 8

Provide a mechanism for cities to pressure the dump site management to implement methane sequestration. When done properly this gas can become a salable commodity actually turning a profit for the operator, but will require some up-front investment. Currently the cities have no control or authority over this, although they are the primary source of much of the emissions.

While many waste materials are economically valuable (for example aluminum, steel, paper and some plastics) and thus readily recycled, there are many potentially recyclable materials which are not currently being recycled in the most efficient manner. This includes organic matter from food and garden waste, glass, tires and electronic refuse.

ACTION 9

While all of the cities interviewed have recycling programs, a large amount of recyclable material still makes its way into the land fills (The Star 2019). Cities should take a more active role in solid waste separation and disposal. Specifically, organic waste (food and garden waste) should be separated and composted to prevent landfilling. Composting, bio-digesters and bio-reactors will give the lowest CO_2 emissions of any treatment method, and can provide useful fertilizer, helping offset the use of fossil fuel based fertilizers (Bokashi 2020, Chan 2010). This is even possible at local levels, such as neighborhoods where a communal composting ground can be located reducing waste transportation emissions.

ACTION 10

Cities need to find an effective method of disposing of problematic recyclable materials such as used tires, e-waste and glass. This may be best done via local commercial recyclers who recycle used tire, or industries such as the cement industry who consume used tires as supplementary fuel (Chemsian 2011). Some recycling service providers will actually buy the recyclables, for example Gcycle, a recyceler in Penang, pays 4RM per used tire (Gcycle 2019)[29].

11.5 INDUSTRIAL TOPIC ACTIONS

One of the areas where city governments have the least coverage is that of industrial emissions. There are, however, several actions cities can take to help insure industries are aware of the importance of efficiency, and are doing all that they can to reduce GHG emissions. While larger companies in general understand the value of energy efficiency, and can appreciate longer term ROIs than individual consumers, there are nevertheless some classes of efficiency and emissions

[29] A list of electronics recyclers is available at: https://says.com/my/lifestyle/e-waste-recycling-malaysia

which bare emphasis. Also, many smaller companies may be completely ignorant of many cost and emissions saving strategies. As such, the aforementioned building efficiency training and team (Action 7) are applicable to industries as well. Additionally, there are a few industry specific areas like burner and chiller efficiency, and electric motor efficiency that should be emphasized.

ACTION 11

Develop a series of efficiency guidelines for industries emphasizing (in addition to typical building efficiency measures) the largest energy consuming processes such as Chiller and Burner efficiency and Electric Motor efficiency measures including use of "Premium Efficiency" motors, the efficiency impact of re-winding motors, proper motor-load matching, use of motor control units such as VFD/Inverters, Soft Starters, Power Factor Correction Capacitors, and Automated Process Controls.

While the entire range of industrial processes may be beyond the capabilities of city officials to track, there are at least two areas of acute emissions problems which do require attention. This includes liquid effluent, and use, production or release of certain high impact gasses such as HFCs, PFCs, and SF_6.

Many industries consume and emit large quantities of water. These include battery manufacturers, chemical plants, steel industries, mining, paper, palm oil and rubber mills, and food processing plants. Generally, larger industrial plants may not be located within a cities boundary, but any of the above industries within a cities jurisdiction should be regularly audited for environmental compliance.

Similarly, any industries utilizing any of the high environmental impact GHG's should be audited on a regular basis. The Department of Environment is responsible for monitoring and control of atmospheric emissions, thus it is suggested that cities form a strong relationship with the DOE for such routine inspections and auditing. Local governments should get training from the DOE, and coordinate project evaluation and enforcement exercises with the state/local branches of the DOE. Working together it may be possible for cities to take on a more active roll in monitoring industrial emissions together with the DOE.

ACTION 12

Form a close working relationship with the Department of Environment for inspecting and auditing industrial gaseous and liquid effluent from high-impact industries (battery manufacturers, chemical plants, steel industries, mining, electronics manufacturing, paper, palm oil and rubber mills, and food processing plants).

11.6 MISCELLANEOUS ENVIRONMENTAL SUSTAINABILITY ACTIONS

Apart from the systemic problems and major contributors discussed above there are several issues of relatively narrow scope which are acutely problematic. These include green belts, river water quality and basic urban planning and environmental leadership, each discussed separately

below.

Malaysia is a very fortunate country in many ways. We have an abundance of natural resources, as well as a diversity of human resources. One striking feature of Malaysia when compared to other ASEAN countries is the prevalence of small urban parks, which is almost completely lacking in many other countries. These parks provide a space for children to play, elderly people to practice Tai-Chi, and for people to generally hang out and relax. Apart from the lifestyle enhancement they also provide significant environmental impact. As mentioned previously a "green belt" adjacent to a building can reduce the buildings energy consumption by as much as 20%. A rigorous accounting of the CO_2 benefits of green spaces, however, is difficult to calculate. Just how many passenger car kilometers per year are reduced because people take their lunch in the park, rather than driving some where? Everyone knows how much cooler it is to drive down a shaded boulevard compared to a blazing hot cement jungle, but exactly how much does it reduce fuel consumption of the cars passing by? Because these contributions are difficult to quantify urban green spaces are sometimes overlooked. Urban green belts need to be encouraged as much as possible, and this can be as simple as planting shade trees along roads, and in parking lots. City administrators need to have a good idea of the positive environmental impact of urban green belts to insure they receive sufficient investment. Also, it is important to consider the impact trees can have on urban infrastructure, such as root induced sidewalk cracking, power and telephone line interference and even fallen tree or branch obstruction of traffic. While urban centers in Malaysia have a much higher percentage of green space compared to other cities in South East Asia, the fraction of green space in Malaysian cities is rapidly falling, suggesting that current policies are inadequate to limit urban expansion at the expense of green space (Nor 2017, Estoque 2013)

ACTION 13

Cities should have a clear idea of the costs and benefits of green spaces within the city. Existing green belts should be protected from encroachment, planned into new developments, and retrofitted in to existing areas as permitted.

Another area not specifically addressed elsewhere is surface water quality. Some cities, notably Johor Bahru, Johor Iskandar and Melaka, have already implemented river clean up plans, tracing the flow of trash back to the source. Additionally, there are various NGOs involved in this area including the Global Environment Center and the WWF (GEC 2010, WWF 2018). Most of this work, however, only addresses floating surface debris, and not the actual water quality. According to the Department of Environment some rivers in Malaysia have a Biochemical Oxygen Demand (BOD) in excess of 20 mg/liter. Anything over 8mg/liter is considered "extremely contaminated" and 20mg/liter is what you might expect for effluent sewage water coming from a treatment plant (DOE 2017). Each kilogram of BOD can result in an equivalent emission of 0.6 kg CO_2 (Ma 2015). Thus, for severely polluted rivers (eg. Sg. Kelantan) which flows at about 500m^3 per second, this results in around 200 tons of CO_2 emissions per year[30]. This indicates that river contamination is yet another significant source of GHG emissions which often goes overlooked. Dirty waterways can be a serious detraction to an urban environment, but clean water ways can actually be an attraction. In 1977 the Singapore River was badly polluted, triggering then prime minister Lee Kuan Yew to order a clean up effort (Times 2014). After many years, and hundreds of millions of

[30] 500m^3/sec x 3600 sec/hr x 24 hr/day x 365day/yr x 0.02gm/liter x 1kg/1000gm x 0.6kgCO_2/kgBOD = 189ton CO_2/year

Singapore Dollars the river front is now an aesthetic enhancement to the surrounding business district and a tourist attraction. Another potentially useful aspect of urban waterways is for use as walking and bicycle paths (as in the case of Fort Collins, Colorado) where river side paths can avoid conflict with surface traffic on roads. Melaka has made great efforts to clean up the Melaka River and make it into a tourist attraction, however despite the cleaning of floating surface trash the river continues to be polluted and "smelly" with many complaints by visiting tourists as well as locals (Hassandarvish 2019, TripAdvisor 2016, Tripadvisor 2018). The KL the "River Of Life" program is another important example highlighting the difference between superficial river clean ups, and actual river water quality. The River Of Life project has been ongoing since 2011 and has cost about 4.4 billion RM, with an ultimate goal of getting the water quality to Class IIB, "suitable for body contact" (Soo 2019). While the water front has been improved with various pedestrian paths, water fountains and lights, the water quality continues to be dirty, still listed as Class III (Chan 2019).

ACTION 14

Active programs of river cleanup including actual water quality measurements and goals, integrating them into the non-motorized transport, and tourism can have a positive impact on CO_2 emissions, as well as lifestyle improvements. Cities should view rivers as a valuable resource to be carefully maintained and integrated into town planning, rather than closing them off as unsightly sewage ditches.

As can be seen, attempting to introduce emissions reduction measures into completed developments is much more difficult than designing them in from the start. Properly insulating a row house can cost as little as 1000RM at the time of construction, but will likely be two to four times that to retrofit in once the building has been finished. Similarly efficient transportation requires incorporation into a city's development plan from the very earliest stages. While many of the city administrators we met were familiar with sustainable urban planning, failure to consider long-term sustainability can result in a serious long-term emissions problem for municipalities. Thus it is recommended that the need for sustainable urban development be stressed to every department, and that every effort is made to keep everyone in the city administration working toward the common goals on an ongoing basis.

ACTION 15

An ongoing program educating city administrators about the needs for sustainable development should be implemented emphasizing sustainability before a development or project begins. Tools and techniques should be provided, and this should also be used as a forum for feedback from the various departments to incorporate their needs and concerns.

Finally, one of the things most required for emissions reductions is leadership. As mentioned earlier Malaysia tends to favor hierarchical government structures where all the authority resides at the top of the pyramid, thus the role of these "leaders" is all the more important. Department heads should lead by example: ride public transport to work, car pool, or bicycle. VIP parking shouldn't be reserved for single user vehicles, but instead should be allocated to electric scooters

and bicycles. Experiments have shown that the greater the *cost* of leadership (ie. hardship posed to the person leading the way) the greater the *effect* it has on others (Van der Heijden 2012). How seriously will the mass of workers at the bottom of the pyramid take the “bike to work” day if they see the boss showing up in his BMW to park in the front row spot? What effect would it have to instead see him bicycling in thirty minutes early, taking a shower, and getting down to business? While we are concerned with facts, data and concrete plans, the truth is that facts rarely influence behavior (Spodek 2019). When our leaders show their commitment by taking public transport two things will happen. First it will impress upon the rest of us that they are clearly committed to efficiency, so it must be a priority, and secondly the administrators are likely to be much more sensitive to shortcomings in the existing public transport system.

Organizational efficiency is also strongly affected by leadership. Centralized bureaucracies can never be as efficient, or adapt to changing situations as quickly as organizations with distributed responsibility. Leaders need to empower their subordinates to make their respective decisions without referring every matter to the top of the pyramid. This requires trust, which in some cases appears to be lacking. If subordinates within governmental organizations can not be trusted, simply put, they should not be working there. If they can be trusted, then they should have the authority to carry out their job without much intervention from above.

As with all government processes, planning and accounting should always be transparent. Data and the decisions made based on that data should be available for everyone to review. Rather than requiring formal letters and extensive approvals to get access to data, environmental data, and indeed nearly all governmental data, should be open access.

ACTION 16

Top level administrators at the federal, state and city level should show by example their commitment to lower emissions. This includes taking public transport when ever possible, and making a conscious effort to live a low-carbon life. Subordinates should be provided the tools and authority to perform their job, and entrusted to do so. Data on which decisions are based, and the resulting decisions should be readily available to all interested parties to analyze. We need to continuously encourage leaders to LEAD by example, empower their staff, and provide them motivation to do the right thing.

12. PRIORITIZED RECOMMENDATIONS FOR NGO SUPPORT

While our analysis has lead us to the recommendations enumerated above, not all of these are strictly consistent with environmentally concerned NGO requirements. Therefore we have prepared this short list of prioritized recommendations for environmental NGOs.

As mentioned at the start, we are interested in identifying ways in which environmental sustainability can be further incorporated into policy at various levels of government. Specifically, we are seeking areas where we can help fill in existing gaps in the governments planning process as well as inter-departmental issues where ARI or an NGO can work to bring the various parties together in a more effective working relationship. These shortcomings may be addressed via various capacity building operations, demonstration projects and information exchanges with the pertinent parties. These are separated into two categories: Overarching actions, and individual "niche" topic actions.

OVERARCHING ACTION #1:
Establishment of a "Carbon Assessment Training Team"

Many municipalities mentioned that they some times feel lost in their quest for sustainability. They do not have all the expertise required to evaluate carbon savings from every project, thus have a hard time prioritizing projects, or even choosing which projects to consider. A wide range of carbon accounting tools exist, but this can actually add to the confusion. Apart from assessing the individual projects they must now select which method to use for the evaluation. What is needed is a dedicated team of experts who are accustomed to assessing city level projects for CO_2 impact and project cost. This team should use a standard set of tools, and work closely with the various cities, not just training them on the tools, but also providing guidance in evaluating the various projects. Best practices from other cities can easily be shared, and when the cities run into problems, they will have additional resources to refer to. This team can be drawn from existing resources within various government bodies, such as DOE, MGTC, MESTECC, outside bodies such as various university experts and NGOs, and even the cities them selves. What is the formation and training of this group via various high-level workshops. Subsequently this core group of experts would work directly with various cities to review and help analyze the current and proposed sustainability actions, while training up the individual city staff on the appropriate tools and techniques.

The challenge will be to get the individuals, who may likely "belong" to different organizations, to work together as an effective team. This will require a solid commitment on the part of each organization, or alternatively, establishment of a new team within a new or existing organization. There is a need for just such "cross department" teams, as well as providing or facilitating training of the team and the city members.

This group should be able to address the CO_2 reduction project cost/benefit needs of the cities (as mentioned in Action 1), as well as providing on-going emphasis and training related to sustainable

development (Action 15). Additionally, the team, being a nationwide body, should have very close relationships with other departments and organizations such as TNB, SW Corp, DOE, JKR and others, facilitating information exchange.

OVERARCHING ACTION #2:
Establishment of a National Association of City Level Sustainability Practitioners

The "Carbon Assessment and Training Team" can also be used as a platform for addressing inter-departmental issues (Action 2) via the establishment of a national level "Association of City Carbon Practitioners". As cities encounter trans-boundary issues or problems related to jurisdiction, this "Association" could then work closely with federal level bodies and concessionaires. The Association will carry much more weight than an individual city administrator, and could more easily get the appropriate contacts within the other government departments, facilitating information exchange (eg. getting local level electricity usage from TNB), and effecting change. For example, such an Association could more easily and uniformly get permission to create bicycle lanes on certain town center roads via direct negotiations with JKR and JPJ. This would allow cities to exert much greater influence over issues involving extra-city bodies (such SW Corp and dump site methane sequestration, ie. Action 8), and many of the other trans-boundary issues highlighted in the study.

Another advantage of a national association would be the regularization of funding for the various emissions abetment projects. The association could communicate to the cities what funds are available for the various programs from both government and external sources. Additionally, the association could lobby more effectively for additional funds, based in part on the results of projects implemented in different locations. This could help streamline the funding mechanisms for emissions reductions, as well as optimize funding to the most effective programs.

Once the basic team has been established, other departments could be invited to national workshops where the various trans-boundary and inter-departmental issues are discussed and, with the help of the various departments, could actually be *solved*. Eventually dedicated liaison personnel in each of the various departments and organizations can be identified, and with buy-in from top management, become dedicated to the city level sustainability programs.

OVERARCHING ACTION #3:
Development of Simple Guidelines for CO_2 Emissions, Energy Efficiency and Sustainability

For many CO_2 reduction projects, a tool or national level standard may exist, but is too complex to be readily interpreted for either project implementers or auditors. This point was mentioned repeatedly by the various cities during interviews, and has been highlighted as a reason for failure of some "green" building initiatives worldwide. What is needed is a simple set of guidelines stating in clear language how a project should be evaluated and what is considered an acceptable design

in terms of energy efficiency and sustainability. This will be one of the main responsibilities of the aforementioned national “Carbon Assessment Training Team”, as well as one of the major tools to be shared with the municipalities. These guidelines should conform to, and perhaps help form, national level standards and policy in much the same way the California Air Resources Board (CARB) develops state level emissions standards for California in the USA which are generally then adopted by the national Environmental Protection Agency (EPA) after some time. The guidelines will have to cover a wide range of different areas including:

- New Building Energy Efficiency Standards (Action 6)
- Existing Building Energy Efficiency Retrofitting (Action 7)
- Solid Waste Separation, Recycling and Composting (Action 9)
- Industrial Efficiency Guidelines (Action 11)
- Urban Green Space Guidelines (Action 13)
- River Cleanup and Contamination Prevention (Action 14)

Within Malaysia there exists a wide range of expertise, and we need to capitalize on the existing resources as much as possible. In order to achieve the greatest impact, standards and guidelines should draw heavily from actual experience of the cities involved in the implementation of the various projects and actions. A major contribution could be made by helping develop the team, and, working with various cities and national experts, develop easy to understand guidelines, and creating a database of case studies. This will greatly simplify the task of the participants in developing efficient low carbon cities with reasonable expectations of carbon reductions and project costing.

NICHE TOPIC ACTIONS

Apart from the over-arching actions mentioned above, there are several potential areas which coincide nicely with an environmentally conscious NGO motivations and goals. In each of the actions below an NGOs ability to promote awareness and develop human resources towards greater environmental stewardship could prove extremely valuable.

RIVER CLEANUP AND CONTAMINATION REDUCTION

A good deal of river contamination is related with the public's attitude. Tossing garbage at the side of the road or into a *longkang* is a personal habit, not directly within the control of the city administration. Here behavior modification is required. Generally, this is a slow process, requiring intervention at the schooling level, and public awareness campaigns. As this is a country-wide problem, and can strongly affect the aquatic wild life, this presents a unique opportunity to have a large impact by uniting the cities efforts on a nationwide basis. Additionally, working together with cities and the Department of Environment, can also help improve river water quality by emphasizing the impact of eutrophication, and aiding cities in tracing water quality problems back to their source.

SOLID WASTE SEPARATION AND RECYCLING

Often cities delegate recycling to third parties. Generally, these “concessionaires” or contractors are primarily interested in recycling profitable materials such as aluminum, paper and steel[31]. Many recyclable materials, such as glass, are often overlooked and become a problem for the cities. Additionally, studies show that almost half of the solid waste in Malaysia is organic material that could easily be “recycled” in the form of compost, reducing the burden on the land fill, reducing CO_2 emissions, and generating useful fertilizer. Currently there are great differences in recycling practices and effectiveness between the various cities. An NGO could take on a major role in helping coordinate and standardize efforts in materials separation and recycling, especially including composting. Simply highlighting the fact that dump sites could effectively double their life span by compositing organic waste instead of land filling will go a long way toward motivating organizations to consider this CO_2 reducing technique. This would involve educating city administrators as to the best practices, and coordinating efforts between the cities, contractors and SW Corp.

BUILDING RETROFIT STANDARDS AND PUBLIC EDUCATION

New building standards are crucial to the long-term sustainability of cities, however the “legacy” existing structures remain largely unaffected by progress in new building efficiency. One of the challenges here is to educate the owners of existing structures to the benefits (in terms of comfort, savings and CO_2 reduction) of existing building efficiency upgrading. Consumers need very straight-forward guidelines and ways to quickly evaluate the cost/benefit or Return On Investment (ROI) of various building improvement options. An NGO could help this via public awareness campaigns, development of standard tools and calculations based on real-world applications of efficiency upgrades, and perhaps helping form a nationwide data base of implemented projects along with their cost and energy-savings.

URBAN GREEN SPACE PROMOTION

A final vital, but often overlooked area is that of urban green spaces. These enclaves enhance the quality of life, and can have a significant impact on CO_2 reduction. However, because of the difficulty in calculating the exact CO_2 impact they may be overlooked in some urban emissions reduction plans resulting in developmental encroachment on existing urban green spaces. An NGO could help highlight the benefits of urban green spaces by providing training on exactly how green spaces impact emissions, provide examples of various case studies, and promoting individual green space projects. This would include both public education programs as well as directly working with the city administrators and national emissions control teams.

[31] From interview with Penang Urban Services Departnemt, 14 August 2019

13. CONCLUSIONS

While initially there was some hesitation, and even reluctance, on the part of various federal authorities to condone this study, the eventual interactions with the individual cities proved to be very fruitful. The level of enthusiasm and encouragement from the cities towards this study, was unmistakable. When the conclusions of this study were discussed with the cites, they were overwhelmingly supportive of the recommended actions and conclusions.

Malaysia is a land of many resources, great vision, and growing prosperity. However, there are still significant issues in our attempt to come to grips with the environmental impacts of our very prosperity. Notably there are some systematic problems of departmental isolation, lack of coordination among the various governmental levels, inadequate sharing of data and responsibility. Additionally, we need a new era of leadership, which leads by example, and allows delegation of authority and responsibility to less senior levels. It appeared that in many cases leaders at the higher levels were relatively poorly informed about the situation faced by the local authorities. When those at the top of the pyramid are more aware of what is going on closer to the bottom of the pyramid, many of the problems highlighted by this study will be easier to overcome.

There is an *urgency* to all this. Every day news carries ever clearer warnings that business as usual will not suffice to prepare us for the future (Dunsmuir 2019). It is our supreme hope that the recommendations presented in this report will be acted upon in the most urgent, and effective manner possible. It has been an honor to have been a part of this important work.

Dr. Horizon Gitano

06-09-2019

Date

14. FURTHER COMMUNICATIONS

For additional information on this report, or to provide feedback on this report, or the project in general, enquires should be directed to the following parties:

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APPENDIX 1: STAKEHOLDER QUESTIONNAIRE

Applied Research International is currently performing a study to identify opportunities for CO_2 reductions from urban centers in Malaysia. The major objectives of this study are to carry out an analysis of the efforts taken by the various cities to reduce overall GHG emissions from their municipality. We hope to identify existing synergies and gaps between various federal, state and city stakeholders and programs, and identify how ARI (or an environmentally concerned NGO) may fill in the gaps.

To asses this we are primarily dependent of information provided by the municipality in coordination with some on-site verification being performed separately. Much of the information will be gathered dusting interviews with the various cities, focusing on what they perceive to be the biggest challenges and opportunities for CO_2 reductions, along with collecting some basic data on CO_2 emissions in order to asses the potential CO_2 reductions possible.

1) EMISSIONS CHALLENGES AND OPPORTUNITIES

1.1 What do you believe are the biggest sources of CO_2 emissions from your municipality?

1.2 What could be done to reduce the CO_2 emissions of cities going forward?

1.3 What barriers exist to implementing effective CO_2 reducing policies?

For example, it could be lack of knowledge on the specific CO_2 emissions various sources within your city, a lack of federal direction, or manpower, difficulty in retrofitting an existing town layout to favor more efficient transport, resistance on the part of manufacturers to implement cleaner practices, etc.

2) WHAT ARE CURRENT EFFORTS AND FUTURE PLANS BEING UNDERTAKEN RELATED TO EMISSIONS

2.1 Tell us about any special programs, or success stories you have related to emissions reductions.

- Preserve, enhance or expand the green spaces
- Reduce fresh water consumption
- Improve Waste Water cleanliness
- Reduce solid Waste Volumes
- Improve Landfill standards (drainage, gas capturing)
- Increase recycling
- Reduce commute time, distance and cost
- Efforts to reduce traffic jams
- Increase public transport ridership, timeliness and efficiency
- Programs to encourage walking/bicycling
- Programs to encourage ride sharing/car pooling
- Reduce electrical power consumption
- Improve Air Quality
- Improve Surface Water Quality

Any comments relating o the cities GHG/CO_2 Emissions and Sustainability are greatly appreciated!

3) EMISSIONS RELATED INFORMATION REQUIRED FROM THE MUNICIPALITY

While we realize that some of the requested data may not be available, we appreciate collection of as much as possible. This will greatly assist us in assessing the potential impact of any changes.

3.1 Basic City Statistics

3.1.1 Total population of the municipality
3.1.2 Working population of the municipality
3.1.3 Total area of the municipality

3.2 Industry

3.2.1 Amount of Industrial area
3.2.2 Number of separate Ind. Parks and Location
3.2.3 Number of workers
3.2.4 Total annual industrial production (RM)

3.3 Fresh Water

3.3.1 Fresh Water Consumption
3.3.2 Number of water processing plants
3.3.3 Sources of water
3.3.4 Number of employees

3.4 Waste Water

3.4.1 Number of waste water plants
3.4.2 Waste Water volume (by plant)
3.4.3 Effluent quality
3.4.4 Effluent destination
3.4.5 Number of employees

3.5 Solid Waste

3.5.1 Number of land fills, and Level Classification (1-5)
3.5.2 Distance to land fill
3.5.3 Number of employees
3.5.4 Number of trucks, fuel usage

3.6 Recycling

3.6.1 Recycling volumes
3.6.2 Materials recycles and tonnage
3.6.3 Where is end-user of materials

3.7 Road Traffic

3.7.1 Vehicular Traffic Volumes (by mode: Bike, Motorcycle, Car, MPV, Bus Truck)
3.7.2 Passengers per Vehicle
3.7.3 Vehicle Kilometers per year
3.7.4 Purpose of trips
3.7.5 Travel (commute) times and distances
3.7.6 Average traffic Flow Speeds (by road and time of day)

3.8 Public Transport

3.8.1 Public Transport modes (Bus, Train, Other)
3.8.2 Routs, Distances

3.8.3 Annual Ridership
3.8.4 Number of stops
3.8.5 Average Trip Cost
3.8.6 Transport Hub Connectivity between Town Center, Airport, Train Central, Bus Station

3.9 Freight Transport
3.9.1 Freight Traffic Volumes Road
3.9.2 Freight Traffic Volumes Rail

3.10 Electric Power
3.10.1 Electrical power consumption (by mode: residential, commercial, industrial, government, school)

3.11 Air Quality
3.11.1 Number of Air Quality Stations
3.11.2 Annual Average Air Quality Index

3.12 Surface Water Quality
3.12.1 Number of Surface Water Quality testing Stations
3.12.2 Annual average Surface Water Quality

Thank you very much for your time and effort! We will be contacting you further to arrange a face-to-face meeting to discuss the details further. Please send the results to our principal investigator:

Municipal Emissions Study (M'sia)
Prof. Dr. Horizon Gitano
Focus Applied Technologies
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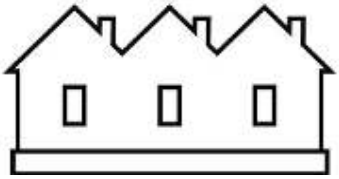
016 484-6524

APPENDIX 2: HOUSEHOLD SURVEY QUESTIONNAIRE

ARI–Focus Applied Technologies One Planet Cities Challenge Survey #: _____

HOUSE TYPE

STAND ALONE HOUSE	ROW HOUSE – SHOP LOT – SEMI-D	FLAT – APARTMENT	OTHER
			

HOW MANY PEOPLE LIVE IN YOUR HOUSE (TOTAL)

1	2	3	4	5	6	7	8	9	10	11-13	14-16	17-20

HOW LONG DOES A 12KG LPG GAS LAST (WEEKS)?

1	2	3	4	5	6	7	8	9	10	11-13	14-16	17-20

HOW MANY OF EACH VEHICLE ARE DRIVEN BY PEOPLE IN THE HOUSE

MPV-SUV	CAR	MOTORCYCLE
		
1 2 3 4 5 6+	1 2 3 4 5 6+	1 2 3 4 5 6+

HOW DO YOU SPEND ON FUEL FOR EACH VEHICLE PER MONTH YEAR: _____ KM: _____

MPV-SUV RM/month					CAR RM/month					MOTORCYCLE RM/month				
50	100	150	200	250	50	100	150	200	250	10	20	30	40	50

WHAT IS THE TYPICAL MONTHLY ELECTRICAL BILL FOR THIS HOUSE?

20	40	60	80	100	120	140	160	180	200-250	250-300	300-350	350+

HOW MANY AIR-CONDITIONING UNITS ARE THERE IN THE HOUSE?

0	1	2	3	4	5	6	7	8	9	10

WHAT CITY DO YOU LIVE IN?

Penang Perai KL JB Iskandar Miri Kuching Kota Kinabalu
Ipoh Shah Alam Melaka Seremban Langakawi Terengganu
OTHER: _____

APPENDIX 3 MEETINGS SCHEDULE

Meetings were held with a few federal bodies, as well as with the various cities, sometimes with follow up visits with different departments. Here is a list of the meeting locations, dates and major participants from the city/federal bodies.

LOCATION	DATE	PRESENT
MGTC	7-03-19	Many Federal Organizations present
USA (Teleconference)	15-03-19	City Nudge Accelerator, Ideas42
MESTECC	4-04-19	Nur Zawani Ibrahim, Suhana, Saifuddin, Jaya Singham Rajoo
MESTECC Eko-Inovasi	9-05-2019	Hartini Mohd. Nasir
Penang	11-04-19	Crystal Chiam Shiying, M. Akbar Mustafa, Zaitun, Shikin, Chew, Fami, Nur Wahidah Zakaria
Perai	12-04-19	Wan Junaidy Yahaya, Siti, Fadzal, Naser, Zabri Bin Mohamed Sarajudin, Mohd Sobri Bin Che Hassan
Petaling Jaya	6-08-19	Lee Lin Shyan, Juanuta, Haizey, Nur Wahidah Zakaria
JB Iskandar Putri	7-08-19	Chew Lee Tien, Safwan Shaari, Nur Afiqah Sabri
Johor Bahru	7-08-19	M. Anariza M. Noor, Tuan Hj. Jalil, Pn. Norbaizura M. Zin, Anariza, Amran, Safwan Shaari, Chew Lee Ting
Ipoh Town Planning	8-08-19	Hj. M. Zainal Abdul Hamid
Penang Urban Serv. Dept	14-08-19	M. Zamzuri Hussain
Sepang	28-08-19	Adham, Raja Shamin Raja M. Naguib, LAr. Ruhaila Rahaman, M. Syahir M. Syaref
Melaka	29-08-19	Pn. Intan, Rohzaina Zainal, Syafrina Yusop
Shah Alam	30-08-19	Noraznizam Alias, Annie Syazrin Ismail
Langkawi City Counsel	12-09-19	Siti Aisha M. Taib, Solihin, M. Faiz Jalaludin, Hezri
SW Corp.	22-01-20	Mimi Marliana Othman, Mohd Safrizal Umar, Azman Mohamad

APPENDIX 4 CITY LOW-CARBON PLANS

Many cities have their own published “Low Carbon” plan, as part of the national LCCF, or related plans under individual topics such as transportation. Below are links to the individual cities published plans, and other relevant websites.

Malaysia's BUR can be found at:
https://unfccc.int/sites/default/files/resource/Malaysia%20NC3%20BUR2_final%20high%20res.pdf

National Low Carbon Cities Framework information is available at:
https://www.greentechmalaysia.my/media/LCCF_Book-Version-2-2017.pdf

MESTECC’s Low Carbon Cities 2030 Challenge is available at:
https://www.mestecc.gov.my/web/en/news/cabaran-bandar-rendah-karbon-2030-low-carbon-cities-2030-challenge-lcc2030c/

Ipoh Local Plan 2035 has yet to be officially published

Johor Iskandar's Low Carbon plan (also covers Johor Bahru) is available at:
https://www.nies.go.jp/unfccc_cop/2014/4.4.pdf

Langkawi Low Carbon Island 2030 (unpublished) mentioned to here:
http://epaper.mmail.com.my/2017/07/12/low-carbon-projects-to-be-launched-in-langkawi/

Melaka's Green City Action Plan is available from:
https://www.adb.org/sites/default/files/related/41571/imt-gt-green-city-action-plan-melaka-april-2014.pdf

Penang Transport Master Plan:
http://pgmasterplan.penang.gov.my/en/

Penang’s Low Carbon Plan is at:
http://pgc.com.my/index.php/penang-green-office-project-to-create-low-carbon-greener-cleaner-healthier-working-environment-in-penang-article?__cf_chl_jschl_tk__=301f529e7c6756f1f05d5d3465a0eacaeb412f07-1580449792-0-Aahp3h5TOqyCMGXA-IHNBMTY3bKrghyQyihG2ta0YZMupskfvTpSc4lw29wLZ5nReRONiLJZVOuFfQMp51pXwn4xzJAw-WgEUgBsEn1GouPdlAD4j_SzNn8CCIRLeEEsdSn3_lYru9NVoE5rwJXb-AkQqJMqUhsZH8aZIQ7PtHfQHZLuzvnFrR4cE4k35VWKWUj5cd_prrjAaEefUQdq3FJsOkfWq--NFRdBqk222lVGSAhc-1s1ArRhlYjhFal7LSYJa3RtoD-nYSCxkrRCh5f2HHrUSsqghkfDts-e16_FgOtg1xcnH6uYaxgi0I6-AweXl8FuTAFRoUGeFWNraJkQv0oWHLQyVu7ZG_5_GaHU2fHMFcUSz6yNFOlX3-hANfiPkY4JPs8b45raRAphlfF-RJr0MAIQqc6aDf3B-qIR

Petaling Jaya's Low Carbon Plan is at:
https://www.carbontrust.com/media/672767/mbpj-low-carbon-city-action-plan-2015-2030.pdf

Perai recently announced it Low Carbon plan (not yet formally published):
http://www.bernama.com/en/news.php?id=1768151

Sepang's Low Carbon Smart City plan can be found at:
www.Smart.MPSepang.gov.my

Shah Alam's Low Carbon plan summarized here:
https://aperc.ieej.or.jp/file/2017/9/20/1510-1530_Review_Expert_Presentation_Shah+Alam_Lin0913.pdf

APPENDIX 5 MALAYSIAN ENVIRONMENTAL REGULATIONS

Rules

Environmental Quality (Compounding Of Offences) (Open Burning) Rules 2000 - P.U.(A) 310/2000
Environmental Quality (Compounding Of Offences) (Amendment) Rules 1999 - P.U.(A) 12/99
Environmental Quality (Compounding Of Offences) Rules 1978 - P.U.(A) 281/78

Regulations

Environmental Quality (Control Of Emission From Diesel Engines) (Amendment) Regulations 2000 - P.U.(A) 488/2000
Environmental Quality (Clean Air) Regulations 1978 - P.U.(A) 280/78
Environmental Quality (Clean Air) (Amendment) Regulations 2000 - P.U.(A) 309/2000
Environmental Quality (Scheduled Wastes) (Amendment) Regulations 2007 - P.U.(A)158/2007
Environmental Quality (Prescribed Premises) (Crude Palm Oil) (Amendment) Regulations 1982 - P.U.(A) 183/82
Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977 - P.U.(A) 342/77
Environmental Quality (Prescribed Premises) Scheduled Wastes Treatment And Disposal Facilities) Regulations 1989 - P.U.(A) 141/89
Environmental Quality (Prescribed Premises Scheduled Wastes Treatment And Disposal Facilities) (Amendment) Regulations 2006 - P.U.(A) 253/2006
Environmental Quality (Prescribed Premises) (Raw Natural Rubber) Regulations 1978 - P.U.(A) 338/78
Environmental Quality (Refrigerant Management) Regulations 1999 - P.U.(A) 451/99
Environmental Quality (Halon Management) Regulations 1999 - P.U.(A) 452/99
Environmental Quality (Scheduled Wastes) Regulations 2005 - P.U.(A) 294/2005
Environmental Quality (Motor Vehicle Noise) Regulations 1987 - P.U.(A) 244/87
Environmental Quality (Industrial Effluent) Regulations 2009 - P.U.(A) 434/2009
Environmental Quality (Control Of Petrol And Diesel Properties) Regulations 2007 - P.U.(A) 145/2007
Environmental Quality (Control of Lead Concentration In Motor Gasoline) Regulations 1985 - P.U.(A) 269/85
Environmental Quality (Control Of Emission From Diesel Engines) Regulations 1996 - P.U.(A) 429/96
Environmental Quality (Control Of Emission From Petrol Engines) Regulations 1996 - P.U.(A) 543/96
Environmental Quality (Control Of Emission From Motorcycles) Regulations 2003 - P.U.(A) 464/2003
Environmental Quality (Control of Pollution From Solid Waste Transfer Station And Landfill) Regulations 2009 - P.U.(A) 433/2009
Environmental Quality (Sewage) Regulations 2009 - P.U.(A) 432/2009
Environmental Quality (Appeal Board) Regulations 2003 - P.U.(A) 115/2003
Environmental Quality (Licensing) Regulations 1977 - P.U.(A) 198/77

Orders

EIA Environmental Quality Order 2015
Environmental Quality (Prohibition On The Use Of Chlorofluorocarbons And Other Gases As Propellants And Blowing Agents) Order 1993 - P.U.(A) 434/93
Environmental Quality (Prescribed Premises) (Scheduled Wastes Treatment And Disposal Facilities Order) 1989 - P.U.(A) 140/89
Environmental Quality (Prescribed Conveyance) (Scheduled Wastes) Order 2005 - P.U.(A) 293/2005
Environmental Quality (Delegation Of Powers On Marine Pollution Control) Order 1994 - P.U.(A) 537/94
Environmental Quality (Delegation Of Powers Halon Management) Order 2000 - P.U.(A) 490/2000
Environmental Quality (Delegation Of Powers) (Investigation Of Open Burning) Order 2000 - P.U.(A) 311/2000
Environmental Quality (Delegation Of Powers) (Perbadanan Putrajaya) Order 2002 - P.U.(A) 233/2002

Environmental Quality (Delegation Of Powers) Order 1999 (Revoked) - P.U.(A) 501/99
Environmental Quality (Delegation Of Powers) Order 2005 - P.U.(A) 365/2005
Environmental Quality (Prescribed Premises) (Raw Natural Rubber) (Amendment) Order 1978 - P.U.(A) 337/78
Environmental Quality (Prescribed Premises) (Raw Natural Rubber) Order 1978 - P.U.(A) 250/78
Environmental Quality (Prescribed Premises) (Scheduled Wastes Treatment And Disposal Facilities) (Amendment) Order 2006 - P.U.(A) 252/2006
Environmental Quality (Prescribed Premises) (Crude Palm Oil) Order 1977 - P.U.(A)199/77

Other Sustainable Development Policies

National Direction
New Economic Model (NEM)
Environmental aspects of the various Malaysia (5-year) Plans
Economic Transformation Program

National Acts
The Merchant Shipping Ordinance (1952)
The Land Conservation Act (1960)
The Street, Drainage and Building Act (1974)
The Local Government Act (1976)
The Town and Country Planning Act (1976)
National Forestry Act (1984)

National Policies
National Policy on the Environment (2002)
National Green Technology Policy (2009)
National Climate Change Policy (2009)
National Renewable Energy Policy and Action Plan (2010)
National Urbanization Policy 2 (2016)

National Plans
• National Physical Plan (NPP)

Regional Plans
• Sabah Development Corridor (SDC)
• Sarawak Corridor of Renewable Energy (SCORE)
• Comprehensive Development Plan (CDP)
• East Coast Economic Region (ECER)

Low Carbon Cities Framework (2017) KeTTHA

APPENDIX 6 HOUSEHOLD SURVEY DATA

Survey	Type		Weeks	Number of Vehicles			Fuel Cost RM/Month			RM/mo	#	Got	
Location	House	Pax	LPG	SUV	CAR	Moto	SUV	CAR	Moto	TNB	AC's	Insulation?	Notes
Perai	RH	2			2			70		70	1		
Perai	SA	5			2	5		110	40	45	0		
Perai	RH	1			1			200		18	0		
Perai	RH	4			4	1		200		160	1		
Perai	SA	5		1	1	1	240		50	80	2		
Perai	SA	7		1	1	4					1		
Perai	SA	3			1	1		150	50	100	0		
Perai	SA	5			1	1		140	40	100	0		
PENANG	SA	5	4		2	1				225	0	Yes	
PENANG	F	4	4		1	1		50		80	1		
PENANG	RH	7	2		3	1		150	60	320	3	NO	
PENANG	F	2	16		2			200		150	2	NO	
IPOH	RH	4		2		1				300	6		
IPOH	RH	3	3	2	2		640			230	3		
IPOH	SA	5	5		1	1			40	110	0		
IPOH	F	1	30		1			300		110	2		
IPOH	SA	4	6	1	1		200	150		145	3		
PJ	SA	5		1	4		400	1100		600	6		
Sepang	F	3	25	1	2	1	150	150	10	140	2		
Sepang	SA	5	11		3	2		200	40	70	0		
Sepang	SA	5	4	1	1	3	200	150	50	70	0		
Sepang	SA	12	4	3	4	4	400	400	50	500	5		
Sepang	F	3	25		1			100		220	3		
Sepang	SA	7			4	4			100	315	2		
Sepang	RH	5	25		1	2		300		40	0		
Sepang	SA	3	4		1	1		200	100	180	1		
Sepang	SA	6			2	4		200		1000	2	NO	AC Always on, par
Sepang	SA	7	7	2	4		200	200			NA		
Sepang	SA	6	2		3		500	500	150	450	3		
Sepang	SA	4	50		2	1		300	30	40	1		
Sepang										300	3		
Melaka1	SA	2	8	1			400			140	2	NO	
Melaka1	F	4		1		1	200		80	80	1		
Melaka1	RH	2	30		1	2		400	200	60	0	NO	
Melaka1	SA	6	5		2	3		200	80	30	0	Yes	
Melaka1	SA	7	4		4	4		300	100	225	1	NO	
Melaka1	RH	6	6		2	1		250	75	180	2	NO	
Melaka1	SA	4	11		2			200		120	2	Yes	
Melaka1	RH	4	3		2			400		70	0	NO	
Melaka1	RH	6	8	1	2	2	100	200		300	2	NO	
Melaka1	SA	10	2		3	2		300	80	400	4		
Melaka1	SA	5	2		3	2		200	50	130	0	NO	
Melaka1	SA	11	2	1	6	1	200	200	50	190	6		Exhaust fan

NOTES:
Data collection took place from June-September 2019 in the stated cities
House types are: Row House, Stand Alone, Flat
LPG is Cooking gas consumption in weeks to consume a 12kg tank
Fuel cost and Electric Bill (TNB) are in RM/month
AC is the number of AC units in the house
Blanks are unanswered or unknown

Survey	Type		Weeks	Number of Vehicles			Fuel Cost RM/Month			RM/mo	#	Got	
Location	House	Pax	LPG	SUV	CAR	Moto	SUV	CAR	Moto	TNB	AC's	Insulation?	Notes
Melaka2	SA	3	30		1			300		100	0	NO	
Melaka2	SA	6	3	1	2	4	250	300	100	300	4	NO	
Melaka2	RH	5	50		2			400		400	4	NO	
Melaka2	SA	4	3		1	1		250	150	60	0	NO	
Melaka2	SA	3	3		2	1		300	50	80	0	Yes	
Melaka2	SA	5	5		3	1		200		30	0	NO	
Melaka2	RH	4	4	1	1	1	200	200	10	160	1	NO	
Melaka2	SA	4	4		3			200		650	7		
Melaka2	SA	5	5		2	1		200	30	200	2	NO	
Melaka2	SA	4	4		2			150		350	3	NO	
Shah alam	SA	8	4	2	1		400	200		70	5		
Shah alam	F	5	E	1	1		500	200		450	4		
Shah alam	SA	7	4	1	3		250	200		120	5		
Shah alam	SA	5	6		2					80	3		
Shah alam	F	5	12		1	1		300	50	260	3		
Shah alam	SA	3	25		1			300		30	0		
Shah alam	SA	9	2.5	1	3		400	425		1800	5		
Shah alam	F	2	12		1			150		70	4		
Shah alam	F	3	25		2	1		300	10	120	1		
Shah alam	F	2	50	1		1	150		50	60	1		
Shah alam	SA	5	12			1		325	150	90	1		
LGK	RH	5	12		1	1		150	30	160	1	NO	
LGK	F	5	12		2	1		200	35	120	1	NO	
LGK	SA	5	25		2	1		200	20	80	0	NO	
LGK	SA	5	50	1	2	3	200	250	30	400	2	NO	
LGK	SA	4	25		2	1		250		100	1	NO	
LGK	SA	1	50		1			80		18	0		
LGK-M1	SA	5	8		2	2		150		70	1		
LGK-M1	SA	6	4		2	2		200	50	150	1	NO	
LGK-M1	SA	5	8	1	1	1	200	200	50	160	1		No Family
Duplicate: This is same house as line above										280	3		With Family
LGK-M1	F	3	8		1	1		200	20	50	0		
LGK-M1	F	2	50		1	1		50		20	0		
LGK-M1	RH	4	8	1	1	1	200	100	20	120	1	Yes	
LGK-M1	G	1	50		1	1		40	10	20	0		
LGK-M1	SA	4	4		1	1		80	20	50	0		
LGK-M1	SA	5	8		1	1		300	150	70	1	NO	
LGK-M2	SA	4	8	1	1		250	150		150	2	NO	
LGK-M2	SA	4	4		2	4							
LGK-M2	RH	3	25		1	1		300	80	20	0		

NOTES:
Data collection took place from June-September 2019 in the stated cities
House types are: Row House, Stand Alone, Flat
LPG is Cooking gas consumption in weeks to consume a 12kg tank
Fuel cost and Electric Bill (TNB) are in RM/month
AC is the number of AC units in the house
Blanks are unanswered or unknown

APPENDIX 7 CAR MILEAGE SURVEY DATA

Years	1000 km	k km/yr
6	184	30.67
	18.5	
13	325	25.00
	159	
24	572	23.83
	282	
9	278	30.89
6	92	15.33
9	200	22.22
2	39	19.50
5	104	20.80
1.5	57	38.00
7	13.7	1.96
15	225	15.00
	205	
15	175	11.67
	205	
	57	
14	363	25.93
3	19	6.33
20	288	14.40
15	305	20.33
11	255	23.18
7	103	14.71
5	70	14.00
8	86	10.75
1.5	7.5	5.00
11	200	18.18
12	210	17.50
8	153	19.13
9	98	10.89
17	200	11.76
11	160	14.55
4	80	20.00

NOTES:
Data collection took place from June-September 2019 in Ipoh and Perai

APPENDIX 8 POTENTIAL FUNDING SOURCES

Municipalities wishing to implement various emissions control plans often require additional funding. The sources listed below are potential sources of emissions related funds.

City Nudge Accelerator
Provides financing for economically viable, environmental projects

The Asian Development Bank (ADB)
ADB has specific funds for many areas including climate change mitigation and adaption.
https://www.adb.org/themes/environment/environmental-initiatives-partnerships/adb-gef

The Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)
GIZ funds a number of policy development projects, specifically has been focusing on electric mobility among other areas.

The International Climate Initiative (IKI)
IKI has been financing climate and biodiversity projects in developing and newly industrializing countries, as well as in countries in transition.
https://www.international-climate-initiative.com/en/about-the-iki/iki-funding-instrument/

Global Environment Fund
This is specifically for Electric Mobility
https://www.thegef.org/project/global-programme-support-countries-shift-electric-mobility

Global Climate Fund
The Global Climate Fund is a global platform to respond to climate change by investing in low-emission and climate-resilient development. GCF was established to limit or reduce greenhouse gas (GHG) emissions in developing countries, and to help vulnerable societies adapt to the unavoidable impacts of climate change.
https://www.greenclimate.fund/home

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