UNIVERSITY OF MALAYA'S LOW CARBON APPROACH: EVALUATION OF CLEAN DEVELOPMENT MECHANISM (CDM) POTENTIAL

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DISSERTATION SUBMITTED IN FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF TECHNOLOGY (ENVIRONMENTAL MANAGEMENT)

INSTITUTE OF BIOLOGICAL SCIENCES
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KUALA LUMPUR

2013

DEDICATION

In the name of the Almighty God, I hereby dedicate this work to my entire family: parents; Sir and Lady B.E. Okere, my dedicated wife; Ijeoma Olivia Okere; lovely children Daniel Chimere BE-Okere and David Sobechi BE-Okere ; elder brother Dr E.C. Okere; elder sister Mrs Vivian Onyeike, younger ones Reverend Bede Okere, Mrs Maureen Okere and Chinwendu Okere.

Furthermore my parents' in-law Mr and Mrs Basil Ohia and entire family share in this dedication.

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To the Almighty God, thanks so much for the life and good health you have given to me especially in the course of this study.

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I acknowledge the unflinching support of my parents' in-law and family including all my friends and relative whose constant contact and prayers energized me more.

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UNIVERSITI MALAYA

ORIGINAL LITERARY WORK DECLARATION

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Registration/Matric No.: **SGH100014**

Name of Degree: **MASTER OF TECHNOLOGY (ENVIRONMENTAL MANAGEMENT)**

Title of Project Paper/ Research Report/Dissertation/Thesis (“this Work”):

“UNIVERSITY OF MALAYA’S LOW CARBON APPROACH: EVALUATION OF CLEAN DEVELOPMENT MECHANISM (CDM) POTENTIAL”

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ABSTRACT

Current human energy use and waste management practices have been associated with massive greenhouse gases emission resulting in climate change. Degradation of the already indebted environment and potential threat to sustainability due to the impacts is on the rise and has led to a unique synergy by world leaders to find antidotes. The United Nations Framework Convention on Climate Change (UNFCCC) through Kyoto Protocol in 1997 practically began championing the remedial effort mainly through one of the flexible mechanisms, Clean Development Mechanism (CDM), by which industrialized nations invest in green developments in developing nations and invariably earn carbon credits for greenhouse gas (GHG) emission reduction with a parallel greening of the development nation.

University of Malaya is among the five pilot centres for low carbon city frame work assessment in Malaysia; hence this study was conducted to ascertain the eligibility of the institution for Clean Development Mechanism (CDM) as its transits to a low carbon campus. The focal points for the evaluation was electricity use and waste management practices as they fall into two of the six sectors eligible for CDM in Malaysia; energy efficiency and waste management.

The objectives have been effectively analyzed adopting a conservatively prudent analysis incorporating primary and secondary data, onsite assessments and evaluation, perusal and integration of associated literature. Finally CDM methodologies AMS 11.N/ version 01.0 and AMS 111.AO./Version 01 are applied.

Evaluation shows a positive trend for both cases; in a case study of the University's main library which forms less than 5% of the total floor area of the institutions building capacity, a CER of 4,841.2 tonnes worth about RM137,974.20 over a ten year crediting period is feasible just for lighting retrofitting. The bill savings from implementing this project activity is worth RM620,224.00 in a decade. The payback period is less than 3 years while the net profit could be about RM477,989.70, an average of almost RM48,000.00 annually. The anaerobic digestion of biodegradable waste for heat and power production also showed that CER of 1,764 tonnes worth RM 50,274.00 yearly is feasible. The annual average electricity generation capacity and bill savings of 55.6MW and RM19,640.00 respectively is estimated while a mega saving of over RM400,000 yearly from diversion of waste from the landfill is of high probability.

There are potential for University of Malaya going for CDM, if the CDM secretariats prescribed procedures are followed, so as to achieve reduction in GHG emission. What could be done in University of Malaya should be replicated in other similar establishments with similar cases.

This investigation is a pilot study of the potential economic and environmental gains accruable with University of Malaya or other similar institutions of same peculiar case participating in CDM. The result from this study has given a green light and encouraged a more detailed analysis on the energy use, waste management and associated technologies and policies for a successful transition to a more sustainable and low carbon campus status.

Keywords: CDM, electricity use, waste management, carbon credit, Kyoto Protocol, greenhouse gas emission.

ABSTRAK

Amalan penggunaan tenaga dan pengurusan sisa semasa dikaitkan dengan pelepasan gas rumah hijau secara besar-besaran, seterusnya mengakibatkan perubahan iklim. Kemerosotan alam sekitar dan ancaman kepada kemampanan kehidupan kian meningkat lalu menyebabkan kesatuan hati antara pemimpin-pemimpin dunia untuk mencari jalan penyelesaian. Melalui protokol Kyoto pada tahun 1997, Konvensyen Rangka Kerja Bangsa-Bangsa Bersatu mengenai Perubahan Iklim (UNFCCC) mula memperjuangkan usaha pemulihan alam sekitar, terutamanya melalui Mekanisme Pembangunan Bersih (CDM). CDM merupakan salah satu mekanisme fleksibel di mana negara-negara maju melabur dalam industri-industri pembangunan hijau di negara-negara membangun. Pelaburan ini akan menyumbangkan kredit karbon serta memampankan perkembangan di negara membangun.

Universiti Malaya merupakan salah satu daripada lima pusat perintis di Malaysia untuk menjalankan penilaian rangka kerja bandar karbon rendah (low carbon city frame work assessment). Maka, kajian ini dilaksanakan untuk menentukan kelayakan institusi ini untuk mencapai status Mekanisme Pembangunan Bersih (CDM) dalam transisi menjadi kampus karbon rendah. Dalam kajian ini, tumpuan diberi kepada penggunaan elektrik dan amalan pengurusan sisa, kerana ia tergolong antara enam sektor yang layak untuk menerima status CDM di Malaysia, iaitu kecekapan tenaga dan pengurusan sisa.

Objektif kajian ini telah dianalisis dengan berkesan, menggunakan pendekatan konservatif dan berhemah untuk menganalisis data primer dan sekunder, penilaian tapak, serta penelitian dan pengintegrasian bahan terbitan yang berkaitan. Akhirnya metodologi AMS 11.N/ versi 01.0 and AMS 111.AO./Versi 01 digunakan dalam kajian ini.

Hasil penilaian menunjukkan trend positif bagi kedua-dua kes yang dikaji. Kajian kes dilaksanakan menggunakan perpustakaan utama Universiti yang berkawasan lantai kurang daripada 5% daripada jumlah kawasan lantai seluruh Universiti. Dijangkakan CER sebanyak 4,841.2 tan yang bernilai RM137,974.20 dalam masa 10 tahun boleh dicapai jika pengubahsuaian lampu dilaksanakan. Penjimatan bil elektrik daripada pelaksanaan projek ini bernilai RM620,224.00 dalam 10 tahun. Tempoh pemulangan kos pelaburan dianggar mengambil masa kurang daripada 3 tahun, manakala keuntungan bersih dianggar berjumlah RM477,989.70 iaitu purata RM48,000.00 setahun.

Penjanaan haba dan tenaga melalui degradasi anaerobik menunjukkan kebolehcapaian CER sebanyak 1,764 tan dan bernilai RM50,274.00. Kapasiti penjanaan elektrik tahunan purata dan penjimatan bil dianggarkan sebanyak 55.6MW dan RM19, 640,00 masing-masing, manakala penjimatan mega dianggarkan melebihi RM400,000 setahun hasil daripada lencongan sisa dari tapak pelupusan.

Universiti Malaya berpotensi untuk mencapai status CDM jika prosedur yang ditetapkan oleh urusetia CDM diikuti agar mengurangkan pelepasan gas rumah hijau. Apa yang boleh dilakukan di Universiti Malaya patut dicontohi oleh institusi lain yang mempunyaiciri-ciriyangsama.

Penyiasatan ini merupakan kajian perintis mengenai potensi keuntungan ekonomi dan alam sekitar melalui penyertaan CDM, yang boleh memanfaatkan Universiti Malaya atau institusi-institusi lain. Hasil kajian ini menggalakkan analisis yang lebih terperinci mengenai penggunaan tenaga, pengurusan sisa dan teknologi berkaitan untuk melancarkan peralihan untuk mencapai status kampus mapan dan rendah karbon.

Kata kunci: CDM, penggunaan elektrik, pengurusan sisa, kredit karbon, Protokol Kyoto, pelepasan gas rumah hijau

ABBREVIATIONS AND ACRONYMS

AEC	Annual Energy Consumption
ANSI	American National Standard Institute
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
BBC	British Broadcasting Corporation
BIPV	Building-Integrated Photo-voltaic panel
CDM	Clean Development Mechanism
CBDR	Common But Differentiated Responsibilities
CEB	Central Electricity Board
CER	Certified Emission Reduction
CFL	Compact fluorescent light
CHP	Combined Heat and Power
COP	Conference of Parties
CNN	Cable News Network
DOC	Degradable Organic Pollutants
DOE	Designated Operational Entity
DNA	Designated National Authorities
DSM	Demand Side Management
EEA	European Environmental Agency
EI	Energy Intensity
EIA	Energy Information Administration
ERPA	Emission Reduction Purchase Agreement
HVAC	Heating Ventilation and Air Conditioning

GDP	Gross Domestic Product
GHG	Greenhouse gas
GULF	Global University Leaders Forum
ID	Internal Distributions
IPCC	Intergovernmental Panel on Climate Change
ISB	Institute of Biological Sciences
JI	Joint Implementation
JPPHB	Jabatan Pembangunan & Penyelenggaraan Harta Benda
KPI	Key Performance Indicator
kt	kilo tonne
kW	Kilowatt
kWh	Kilowatt hour
LCCF	Low Carbon City Framework
LEO	Low Energy Office
MIT	Massachusetts Institute of Technology
Mm^3	million cubic meters
MW	Mega watt
MWh	Mega watt hour
GWh	Gigawatt hour
NASA	National Aeronautics and Space Administration
NUS	National University of Singapore
OECD	Organisation for Economic Co-operation and Development
PDD	Project Design Documents

PIN	Project Identification Note
PTM	Pusat Tenaga Malaysia
PWD	Public Works Department
RM	Ringgit Malaysia
SB	Switch Board
SWDS	Solid Waste Disposal Site
tcf	trillion cubic feet
tCO_2e	tonnes of carbon dioxide equivalent
TFA	Total Floor Area
TIF	Thermal Interactive Effect
TNB	Tenaga Nasional Bhd
UK	United Kingdom
UM	University of Malaya
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCAP	UnitedNations Economic and Social Commission for Asia
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
UTM	Universiti Teknologi Malaysia
ZWC	Zero Waste Campaign

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FC	Fuel contribution in power plant
PE	Total GHG emission
EF	Emission factor of fuel types
CP	Percentage contribution of various power plants to electricity generation
i	Type of fuel
j	Type of power plant
y	Year of fuel contribution to power plant
η_O	Thermal efficiency of power plants
Q_E	Amount of electricity consumption by UM including 10% transmission loss in MWh

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Human induced Greenhouse Gases (GHGs) emission is a major environmental externality associated with plethora of global warming, thereby erratically changing climate dynamics. Inefficient energy use and poor waste management have contributed to this threat to stability of global environment, correlating in economic losses. The annual economic deficit due to this change according to Akorede et al. (2012) currently amounts to $125 billion (RM381.25 billion), and by 2030 if no serious mitigation actions are taken from now to drastically reduce GHG release then a colossal annual economic loss of $600 billion (RM 1.83 trillion)is eminent.

Climate change scientists have put forward predictions that climate change is due mainly to combustion of fossil fuel and Intergovernmental Panel on Climate Change (IPCC) has predicted worst earth warming in history (Omer, 2008). These may be happening faster than expected considering the recent issues associated with climate change, for instance in 2010; ice measuring 250km^2 broke off Petermann's glacier and most recently an iceberg twice the size of Manhattan, about 120km^2 broke off the same source as observed by National Aeronautics and Space Administration (NASA) satellite on July 16-17 2012 and according to CNN.com, NASA has associated these to climate change. Recently in Nigeria, worst flood in decades due to swollen rivers killed about 150 persons, made almost 140,000 people homeless, destroying farmlands and displaced dangerous animals like crocodiles and hippopotamus into people's homes (BBC, 2012; CNN, 2012). Drought in East Africa and the Sahel region of West Africa affecting about 13 million people (BBC, 2012), typhoon Bhopa that killed over 500 people in Philippines and in July, 2012 worst drought in USA in 60 years. The different stated climate change scenarios including the recent flooding in Malaysia are just a few among many cases.

Global climate change is a threat to the ability of the future generation to meet their needs. The most essential GHGs are carbon-dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). However CO_2 is a standard for GHG quantification (assigning CO_2 a global warming potential (GWP) of 1. Other gas warming potentials could be expressed on a CO_2 equivalent basis, that is their ability to take up heat as compared to CO_2; CH_4 and NO_X have GWP of 21 and 298 respectively (IPCC, 2007; Akorede et al. 2012). Oh & Chua (2010) and Nevers (2000) agrees that from a pre-industrial level of less than 300ppm CO_2 concentration has escalated to about 400 ppm. Future potentials environment model by IPCC estimates that by end of 2100, average worldwide temperature would have risen in the range 1.1 -6.4˚C (Akorede et al 2012) relative to 1980–1999 and for atmospheric CO_2 to be kept at less than 550 ppm by 2050, most scientists according to Oh & Chua (2010) are unionized in agreement that 30-60% reduction of carbon emission must be made for a corresponding 2.4-2.8˚C temperature rise limitation matched to pre-industrial levels.

The United Nations Framework Convention on Climate Change (UNFCCC) through Kyoto Protocol in 1997 made a bold move to develop a process of climate change mitigation through one of the flexible mechanisms, Clean Development Mechanism (CDM) which was established under Article 12. This is a mutual relationship between developed nations termed as Annex 1 countries and developing countries termed as non-Annex 1 countries where the industrialized nations invest in cheaper (as compared to same volume of investment in their country) green developments in developing nations and invariably earn carbon credits for greenhouse gas (GHG) emission reduction, helping them to meet their emission reduction targets. This also helps the non-Annex 1 countries to develop a greener economy.

In 2009 the total electricity generated in Malaysia was 103.2 Twh and is expected to increase to 274 Twh in 2030; over 90% of the fuel mix in Malaysia is non renewable with a projection of just 5.5% and 11% renewable source contribution by 2015 and 2020 respectively according to the 10^{th} Malaysian Plan.

Between 1976 and 2008, Malaysian GHGs emission grew at an average of 14.81%, 10.32%, 14.38% and 21.52% for CO_2, SO_2, NO_X and CO respectively, with a total power plants emission of about 400 million tCO_2e in 2008 (Shekarchian et al, 2011).

Using Malaysian CDM Handbook as a guide at RM47/tCO_2e and with a very conservative assumption that 25% of the total 2008 emission in Malaysia was mitigated, this would mean Certified Emission Reduction (CER) valued at RM 4.7 billion (RM4.7/Euro) would have accrued to Malaysia.

The purpose of conducting this work is to identify the potentials in present energy use and waste management practices in University of Malaya (UM) in building more efficient measures that would enhance the institution's eligibility for CDM assessment.

1.2 Problem Statement

The total consumption of electricity in UM is on the constant rise with associated high bill. Energy source in Malaysia is highly domiciled on fossil fuel, so with the consumption status in UM, there could be serious environmental compromise; also the energy rate is rising due to the epileptic prices in the international energy market.

UM generates about 5 tonnes organic waste daily (2011/2012 figure), out of which less than 20% is composted. A very negligible part of the inorganic waste is recycled making the remainder to be landfilled. It is estimated that a tonne of organic waste could generate 150 litres of leachate in the landfill (Agamuthu, 2011; Bavani, 2009) and decomposition of 1 tonne of organic waste has a potential to release 50-110m^3 of CO_2 and 90-140m^3 of methane into the atmosphere (Macias-Corral et al., 2008).

With the Clean Development mechanism on board and the Ministry of Energy, Green Technology and Water announcement that University of Malaya among four others ;Miri City Council, Pulau Sahbesar in Kenyir, Port Dickson Municipal Council and Hang Tuah Jaya in Malacca have been identified as pilot centres for Low Carbon City Framework (LCCF) assessment (Star ePaper, February 28,2012); the university stands a good chance to rake in economic and environmental benefits if it achieves the low carbon city status. By extension it could also offer a plus to Malaysia's pledge at the Copenhagen climate change summit of 40% carbon emission intensity reduction by 2020 as against 2005 level.

Energy efficiency and waste management offers part of the projects eligible for CDM (discussed further in Chapter 2). Hence in this dissertation we shall assess the energy use and waste management practices in University of Malaya and look at the potential for CDM assessment as the institution transits to a low carbon community.

1.3 Objectives of the study:

1. To determine energy consumption and ascertain waste management practices in University of Malaya.

2. To estimate the greenhouse gases emission from University of Malaya related to energy consumption and waste management practices.

3. To evaluate the eligibility of UM for CDM

4. To estimate the potential environmental and economic benefit of greenhouse gases reduction from energy and waste management in University of Malaya through Certified Emission Reduction (CER).

1.4 Research Scope:

The limited time frame of a semester for this study guided the scope of this study. The focus of this research is on University Malaya's main campus at Kuala Lumpur. However the University of Malaya Medical Centre (UMMC) is exclusive. As for the activities, only energy consumption and waste generation were looked into due to lack of data for other activities. Also, the energy consumption here is strictly on electricity consumption using data from the duration of 2007-2012. The waste aspect of the study considers only biodegradable waste.

1.5 Organisation of the thesis:

This thesis consists of six chapters organized as follows:

Chapter 1 gives a concise introduction into the research topic. It starts with a background on the overview of human activated climate change. It introduces CDM as a remedial effort to tackle climate change. Objectives of the study are also sketched in this chapter.

Chapter 2 provides a literature review for the study. CDM and Kyoto Protocol are studied. In addition fossil fuels and associated issues and also elements of major energy concerns are reviewed in this chapter.

Chapter 3 gives an elaborated detail of the study methodology for achieving each of the objectives. It consists of data used for estimating power plants primary fuel contribution to power generation in Malaysia, method of estimation on non available data and the CDM methodologies applied.

Chapter 4 documents and describes with illustrations all the results obtained and analysed using the described methodology.

Chapter 5 showcases a general discussion on the issues associated with climate change on which the CDM is benched. In this chapter highlights of some inefficiency in electricity consumptions are also elucidated.

In Chapter 6, the conclusions drawn from evaluation of findings are summarized. Furthermore recommendations for a more sustainable campus operation that would enhance a transition to a low carbon campus as well as stronger base for CDM projects activity participation are made.

CHAPTER TWO

LITERATURE REVIEW

2.1 Brief background of University of Malaya

University of Malaya (UM), the premier university in Malaysia has its core origin dating back to 1905 with the establishment of King Edward V11 College of Medicine with population of less than 30. The merging of King Edward V11 College of Medicine and then Singapore based Raffles College (established in 1929) in 1949 gave birth to the nomenclature University of Malaya. Consequently the institution has metamophosized in all aspects and presently has a population of about 29,000 and ranked 156th in 2012 QS universities world ranking.

The institution main campus is located on geographical coordinates 3°07′15″N 101°39′23″E, having a landmass of 309 hectare (750 acre) in the southwest of Kuala Lumpur, the capital of Malaysia with over 450 buildings of total floor area of 11,719,680.96 ft^2 (UMJPPHB, 2012). Figure 2.1 is the campus map depicting main buildings.

Figure 2.1 Map of University of Malaya Campus

Source: UM website, 2012.

2.2 Review of Clean Development Mechanism and Kyoto Protocol milestone

'Historic and moment for humanity', a statement by Maurice Strong the secretary general of United Nations conference on Environment and Development (UNCED) at the end of the Rio de Janeiro "Earth Summit" in 1992; a strong statement and major aspect of the global common front towards tackling excesses of mankind that has put the globe on a dangerous trajectory. The 'Earth Summit' where the United Nations

Framework Convention on Climate Change (UNFCCC) one of the major policy structure for climate change mitigation was adopted is in pursuant of the aims of the 1972 Human Environment Conference in Stockholm in a series of climate change mitigation actions leading to the climate change summit termed Kyoto Protocol. Kyoto Protocol was adopted by world leaders on December 11, 1997 in Kyoto, Japan to tackle climate change. According to UNFCCC, the focus of the Kyoto protocol is that it sets binding targets among 37 developed countries and the European countries for "..stabilization of greenhouse gas concentrations in the atmosphere at the level that would prevent dangerous anthropogenic interference with the climate system". This binding target which is for reduction of 5.2% between first committal period of 2008-2012 is to be measured against 1990 level. Comprehensive channels for enforcement of this protocol termed 'Marrakesh Accords' were adopted at the Conference of parties COP 7 in 2001 and it finally came in force in 2005. Three market incentive based mechanism put on board to help countries achieve their emission commitment are:

1. Emission Trading Scheme (ETS)

2. Clean Development Mechanism (CDM)

3. Joint Implementation (JI)

The mechanisms help to enhance green development with corresponding effect of reduced greenhouse gas emission.

For the purpose of this dissertation, discussion will focus on the Clean Development Mechanism (CDM) because it is applicable to Malaysia as a developing country. Article 12 of the Kyoto Protocol describes CDM, a major base for Kyoto offsets (Spash, 2010); as a relationship where developed nations termed Annex 1 parties with emission commitment earns certified carbon credit for implementation of carbon emission-reduction projects in developing nations, termed non-Annex 1 parties, without any legal commitment. This emission reduction must be an additional to what would have ordinarily occurred without project implementation.

The Clean Development Mechanism offers an economic platform for sustainable synergy between Annex 1 and non-Annex 1 countries. The dynamics of the mechanism is as depicted in Figure 2.2.

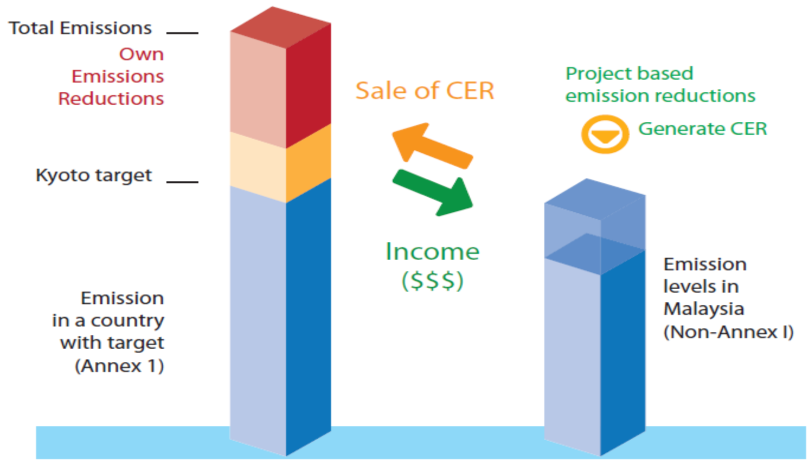

Figure 2.2 CDM in practice

Source: Malaysia Energy Centre (2009).

The first bar (longer) in Figure 2.2 depicts total emissions from an Annex 1 party. To achieve the Kyoto target which is the lower part (blue), reductions would have to be made via internal and through investment in non-Annex 1 country, since due to tighter environmental regulations in Annex 1 countries it might not be cost efficient to internally meet the set standard. The second bar depicts total emission in a non-Annex 1 country. Based on CDM project activated reductions, compliance of Kyoto target could be met by the developed country. This is done by transfer of funds to the developing country and the developing country will reciprocate by transferring the project based reductions termed 'Certified Emission Reduction' (CER) to the developed nation so as to comply with their Kyoto target. Table 2.1 shows the projects accessible under CDM in Malaysia.

2.2.1 Project Cycle

The project cycle is the structural flow of CDM project activities. It is normally started officially with the Project Idea Note (PIN) which is the concise description of the project scope. Figure 2.3 specifically showcase the structure of the Malaysian national project cycle. We see that further detail on the PIN is now done in the Project Design Document (PDD). Here the structure of the projects is detailed such as projection of the GHG reduction and the plan for monitoring and verification of the GHG emissions. The project is registered as a CDM project category after more steps including the validation of the PDD by the Designated Operational Entity (DOE) and approval letter issued by the Designated National Entity (DNA) based on the validation report by DOE. During the implementation of the PDD, the project operator from the host country has to monitor it along with the corresponding emission reduction that is verified by the DOE. Issuance of Certified Emission Reductions (CERs) marks the success of the CDM project activity. This CER must be issued after confirmation statement by DOE. The duration under which the CER is valid known as the crediting period is seven years which is renewable twice or a non-renewable period of ten years.

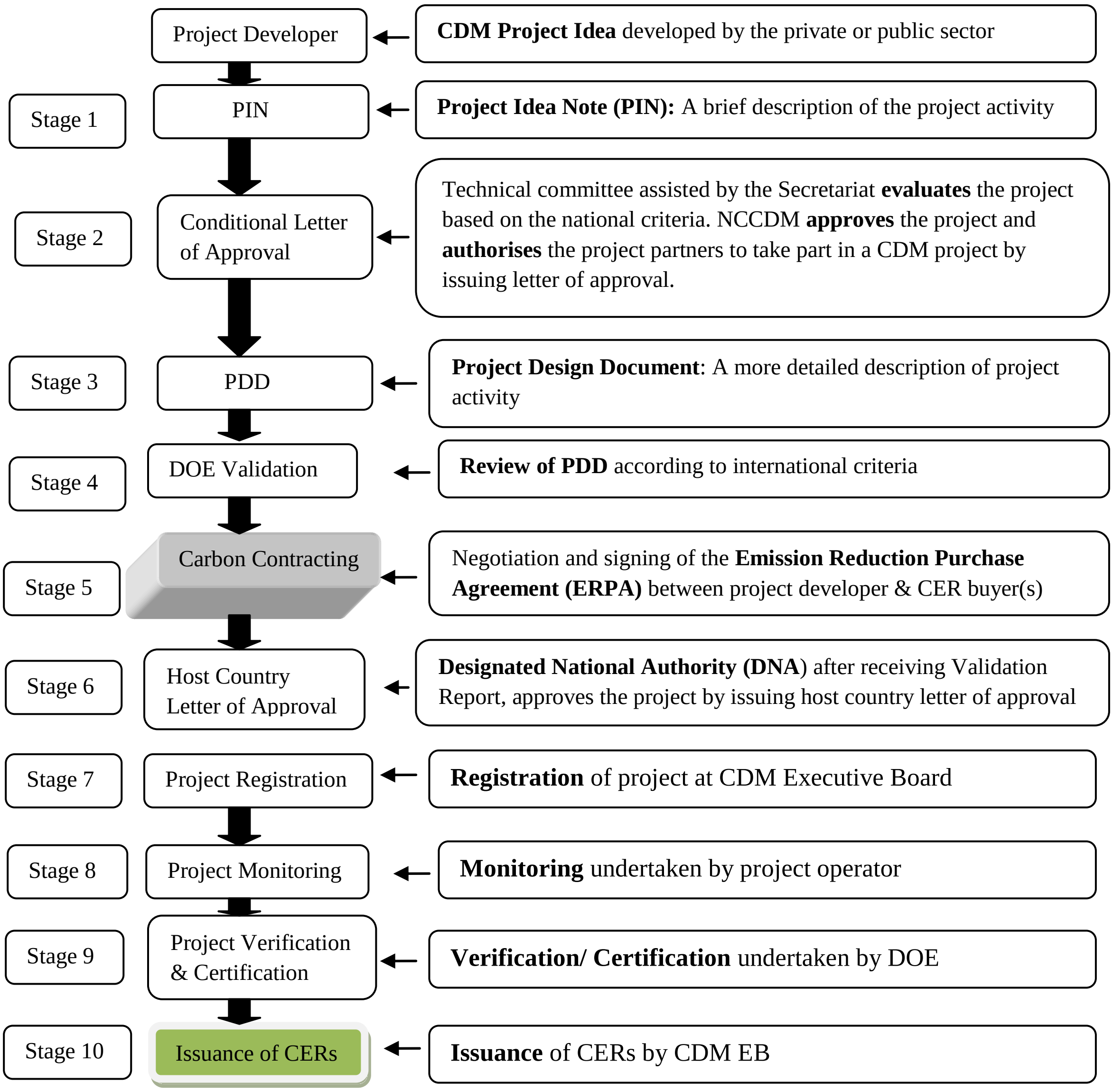

Figure 2.3: National CDM Project cycle

Source: Malaysia Energy Centre (2009)

According to UNFCCC, there were about 4637 registered CDM projects as at September 2012 with expected CER of almost 2.2 billion by end of 2012. Large scale projects which are projects activites with complex modalities and procedures like renewable energy projects of capacity more than 15MW, energy efficiency improvement projects with output more than 60GWh per year or other project activities that could yearly reduce more than 60kt CO_2 equivalent comprised of 59%. Small scale project activities make up 41%. These are project activities with simplified modalities and procedures with ceiling output 15MW, 60GWh annually and 60kt CO_2equivalent annually for renewable energy, energy improvements and any other project activities respectively (UNFCCC, 2012). Figure 2.4 shows the percentage domiciliation of the projects in host countries. Malaysia has 110 projects amounting to 2.37% out of the total.

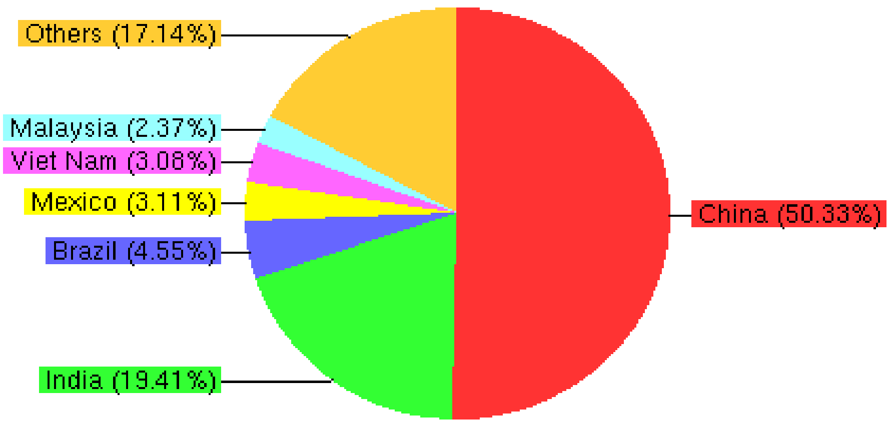

Figure 2.4: Percentage of CDM Projects in host countries

Source: UNFCCC (2012)

Though doubts exist about the future of the carbon market, Paragraph 190-192 of the Rio+20 outcome has provided a platform for future carbon market hope. In paragraph 190, the leaders reaffirms that climate change is one of the major challenges facing mankind with vulnerability more on the developing countries. Paragraph 191 emphasized on building of global synergy to keep worldwide average temperature at 2˚C or 1.5˚C above pre-industrial levels on the basis of equity in harmony with their common but differentiated responsibilities (CBDR). Finally in Paragraph 192, an urge to parties to the UNFCCC to fully implement their Kyoto commitment is noted. The Conference of Parties 18 (COP 18) held in Doha just extended the Kyoto mechanism till 2020.

Table 2.1: CDM Feasible projects in Malaysia

Sector	Type of projects
Renewable Energy	• Biomass power generation – on-grid and off-grid • Biogas power generation from POME, animal waste etc. • Solar: Solar water heating; solar photovoltaic systems • Hydro: Mini-hydro power
Energy Efficiency	• Improving efficiency in electricity production • Improving combined heat and electricity production • Improved boilers; more efficient process heat and steam systems • Fuel switching • Energy efficiency through demand side management
Forestry	• Afforestation • Reforestation
Waste Management	• Power and heat production from wastes • Gas recovery from landfills • Anaerobic waste water treatment
Transport	• Efficiency improvements for vehicles • Switch to fuel systems with lower emissions
Agriculture	• Composting of agriculture wastes • Methane abatement from animal waste • Methane reduction in rice cultivation

Source: Malaysia Energy Centre (2009)

2.3 Malaysia Energy Policies

Articulated energy policies have become very vital in the face of potential bleak future for energy security if the present business as usual continue in decades of years to come. The United States Energy Information Administration has predicted that energy consumption rate will jump by 53% in the year 2030 with the developing countries contributing about 70%. The enormous growth in the developing regions according to Shekarchian et al (2011) is because of expansion in the construction; transport and other sectors. The MRT project in Malaysia which is a 51km mass transit with 35 stations and 2 depots and estimated to cost more than RM8 billion is definitely to be associated with huge embodied energy upon completion.

In the modern era, climate change has risen to be the greatest challenge of mankind. Consequently good policies become essential. Oh et al. (2010) said that the first energy associated policy of Malaysia was in 1949 with the creation of Central Electricity Board

(CEB) responsible for electricity generation, transmission and distribution which was later renamed National Electricity Board (NEB) in 1965. The global oil crises of 1973 and 1978 lead the way for the Malaysian Government to seriously consider sufficient and consistent supplies of energy as top priority, hence the 1974 petroleum development Act establishing PETRONAS (Oh et al. (2010), 1979, 1980 and 1981 Energy Policy, the National Depletion Policy and the four fuel diversification policy respectively (UNDP, 2010). In 1999 renewable energy was added to make it Five-fuel diversification policy. The structure of these is hinged on adequate supply, the utilization and consideration for the environment objectives. Malaysia development plans in the last 3 decades have been hugely dependent on these.

Table 2.2 shows how the policies have shaped the energy sources; oil/diesel was the highest in 1980fuel mix and after quarter of a century it dropped to 2.2% as other sources like coal were seen as abundant which has changed from 0.5 contributions to 22% during same period.

Malaysian Government has launched the National Green Technology Policy and it seeks to further enhance efficiency in energy use.

Table 2.2 Energy Source Dynamics in Malaysia

Source	1980 (%)	1990 (%)	2000 (%)	2005 (%)	2010 (%)
Oil/diesel	89.7	71.4	4.2	2.2	0.2
Natural gas	7.5	15.7	77.0	70.2	55.9
Hydro	4.1	5.3	10.0	5.5	5.6
Coal	0.5	7.6	8.8	21.8	36.5
Biomass	-	-	-	0.3	1.8

Source: Ninth Malaysia Plan (2006-2010)

It is also worth of mention that in pursuit of the Malaysian Government to align to sustainable energy management policies, Energy Commission was established on May 1 2001 under Energy Commission Act of 2001 which took over from the dissolved Department of Electricity and Gas Supply (Malaysia Energy Commission, 2011). They are responsible for the regulation of the energy sector mainly the electricity supply and piped gas supply industries in Peninsular and Sabah.

The National Biofuel Policy of 2006 supports the five fuel diversification policy. This is aimed at encouraging setting modal shift to renewable fuels from fossil fuels (Oh and Chua, 2010). Overall there are 27 licensed independent power producers (IPP) in Malaysia with a combined licensed generating capacity of 16,766MW (Malaysia Energy Commission, 2011)

2.4 Energy Mix in Malaysia

Malaysia currently has five primary fuel sources. The fuel mix comprises oil, natural gas, coal, hydro and biomass. Emission factors associated to the power plants are as shown in Table 2.3

Table 2.3 Emission factors (kg/kWh) in power plants

Fuel Type	CO_2	CO	NO_X	SO_2
Coal	1.18	0.0002	0.0052	0.0139
Natural gas	0.53	0.0005	0.0009	0.0005
Fuel oil	0.85	0.0002	0.0025	0.0164
Diesel	0.85	0.0002	0.0025	0.0164

Source: Shekarchian et al (2011), Mahlia (2002), Saidur and Mahlia, (2010, 2011)

2.4.1 Natural Gas

Natural gas in Malaysia was discovered in 1983 (Oh et al. 2010). Total proven reserve as at early 2008 was about 88 tcf (Oh et al. 2010; Shafie et al 2011). This is an improvement of almost 17.5% over the previous year's figure given by Sulaiman et al. (2011).Almost 90% of the natural gas reserves are domiciled in the offshore of Sabah and Sarawak, most in Sarawak with over 50% of the quantity (Islam et al 2012). Malaysia is ranked first and 12th in natural gas production in South East Asia and the world respectively. Natural gas has risen in its contribution of the country's energy mix to become the main contributor (Table 2.2). In 2008 natural gas fraction of total primary energy contribution in Malaysia was 43.4% (Ong et al.2011; Islam et al. 2012); an increase of 15.5% over 1990 figure.

There are three LNG liquefaction plants in Malaysia located in Bintulu, Sarawak. This massive LNG complex is the largest natural gas processing company worldwide, with a production capacity of 22.7 million tonnes, equivalent to 1.1 tcf per year (Oh et al. 2010; Islam et al 2012).Domestic utilization has substantially increased hitting 1.2Tcf in 2004, 47% more than 2000 consumption (Sulaiman, 2011). Malaysia was responsible for 15% of global LNG export totaling 21.2 Mt in 2005 (Ong et al.2011).

2.4.2 Coal

Malaysia has vast coal resources located in East Malaysia and Peninsular. Estimation shows that Malaysia's coal reserve is about 1.7 billion tons with about 274 million, 347 million and 1.1 billion tons measured, indicated and inferred respectively (Oh et al.2010; Sulaiman et al. 2011). Figure 2.5 shows Sarawak has the highest quantity. Nevertheless in the face of rising demand and abundant coal reserve, Malaysia's exploration of coal has been relatively small. Thus Malaysia remains a net importer.

Malaysia's demand for coal was 15 million ton in 2008 (Oh et al. 2010). In the same year, only 1.17 million tons (Ong et al.2011) were locally sourced with the short fall in local consumption requirement imported from Australia, China and Indonesia.

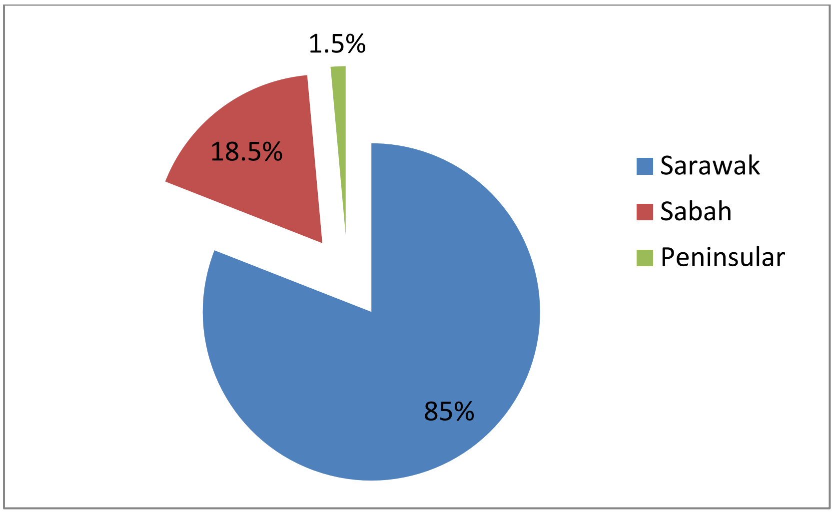

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Figure 2.5 Percentage localization of Coal in Malaysia

Source: Oh et al. 2010; Sulaiman et al. 2011

2.4.3 Oil

In Malaysia the foremost oil well was discovered on Canada Hill in Miri, Sarawak in the year 1910 (Islam et al 2012). The global oil crises of 1973 and 1979 (Ong et al.2011; Oh et al. 2010) were instrumental to some policy twist. In 1974 Petroleum Development Act saw the establishment of Malaysia's national oil company PETRONAS (Oh et al. 2010) which regulates the upstream and downstream of the petroleum sector. Thus exploration thickened. In 1990 crude oil contribution to the primary energy supply in the country was 12.4Mtoe which was highest (Ong et al. 2011). As at 2008 there were 68 oil wells in Malaysia (Shafie et al 2011) with reserves of about 5.5 billion barrels, 68% located in East Malaysia of Sabah and Sarawak (Malaysia Energy Centre, 2009). Local consumption in 2009 was 536,000 barrels per day and 157,730 was exported (Shafie et al 2011). This is down from combined local consumption and export quantity of 798,000 barrel/day in 2006 (Sulaiman et al. 2011). The implication is that even at the present local and export consumption rate, it could be exhausted in less than 22 years.

2.4.4 Hydropower

Hydropower electricity generating efficiency in modern times is about 90% (Dursan and Gokcol, 2011), hence this renewable energy is gaining prominence in nations like Denmark, Ireland, Spain, Portugal and Norway (Catalao et al., 2011; Catalao et al., 2012). However its contribution to global primary energy mix grew by less than 1% in almost three decades as elucidated in Table 2.4 probably because of many issue including high capital cost, high potential for resettlement, lack of improvement on community welfare and even legal issues (Dursan and Gokcol, 2011; Sovacool and Bulan ,2011; Ong et al.2011).

In Malaysia hydropower is the single renewable energy technology that is feasible on a commercial scale with a potential of 29,000MW but only 7.2% utilization in 2008 (Ong et al.2011). There were 12 large scale hydropower dams and 51 small scaled dams in Malaysia in 1990 (Ahmad et al. 2011). Malaysia's average annual rainfall of 2,000-4,000 mm (Malaysia Energy Commission, 2012), which is more than global average of 750 (Shekarchian et.al 2011) makes hydropower viable.

Sarawak Corridor of Renewable Energy (SCORE) is about the largest investment in hydro energy in Malaysia. Total investment in this project that will be using at least 12 hydroelectric dams along a 320 km corridor by year 2030 is US$105 billion (RM 320.25 billion) (Sovacool and Bulan, 2012) and it is expected to deliver about 28,000MW of power upon completion (Oh et al. 2010; Sovacool and Bulan 2012). This could help to alleviate the projected increase in energy demand in Malaysia and possibly reduce the country's per capita carbon footprint.

Table 2.4 Global Primary energy Trend

Source	1980		2008	
	MToe	Share (%)	MToe	Share (%)
Petroleum	2,979.8	44.9	3,927.9	34.8
coal	1,807.9	27.3	3,303.7	29.2
Natural gas	1,296.8	19.6	2,726.1	24.1
Nuclear	161.0	2.4	619.7	5.5
Hydropower	384.3	5.8	717.5	6.4
Total	6,629.8	100.0	11,294.9	100.0

Source: (Ong et al.2011)

2.4.5 Biomass Energy

Biomass energy in the recent past is gaining attention especially in a country like Malaysia. It is a renewable energy and is highly sorted mainly because of its abundance. United States Energy Information Administration has projected that by 2017, biomass energy will be twice the price of natural gas. It contributes about 45EJ of energy which is 10-15% of world energy use (Ong et al.2011). In 1990 it was added as the fifth fuel source in Malaysia when the four fuel diversification policy was replaced by the Five Fuel Diversification Policy. However the government of Malaysia target of 5% biomass contribution in the nation's cumulative energy mix in 2010 was just 20% successful.

2.5 Fossil Fuel Derived energy and Externalities

Three main forms of fossil fuel exist: coal, oil and natural gas. They were formed several millions of years ago, a period called 'carboniferous' before the time of dinosaurs (which gave it the name fossil fuel) between 286 and 360 million years ago

(California Energy Commission, 2012). It went further to enumerate that during the carboniferous period dead trees submerged to the underneath of swamps of oceans forming peat layers which are layers of spongy material. Sedimentary rock resulted after several hundreds of years of sand, clay and other minerals covering the peat. Piling of rocks continued and with the weight heavily increasing, the peat under got squeezed and liquid came out of it and after several millions of years it turned into coal, natural gas and petroleum. These forms of fuel which has taken hundreds of millions of years to form are non renewable.

Primary energy supply in 2008 according to USEIA (2011) was 12,267 million tons of oil equivalent (Mtoe). Fossil fuel forms about 80% of global energy production (Hook et al 2012; USEIA, 2011).

Based on 2005 fossil fuel proved reserves according to Sovacool (2011) as shown in Table 2.5, a gloomy longevity beckons as coal with highest longevity could be exhausted in less than 50 years. The negative externalities associated with the use of these non renewable resources are even higher than the existing price of the electricity they produce. Sovacool (2011) has shown an example of this by stating that damages caused by the electricity sector in USA amounted to about $420 billion (RM1.28 trillion) in 2006 which was about 52% more than the total electricity revenue.

Boden et al (2010) mentioned that about 337 billion tonnes of carbon from use of fossil fuel and cement production has been released to the atmosphere since 1751 and half of this has been released after 1974 and further went on to say that 70% of the total emission in 2007 which amounted to 6 billion tonnes was from liquid and solid fossil. In 2005, CO_2 emission from fuel combustion in power generation made up about 25% of global human emitted GHG (Soimakallio and Saikku, 2012; Graus and Worrel, 2011). Therefore fossil fuel is a major contributor to global warming. Thus optimum efficiency in its use is essential while it is more important to shift more resources to developing renewable sources of energy.

Table 2.5 Life Expectancy of proved fossil fuel reserve

	Proved reserves(2005)	Current production (2006)	Life expectancy (years)		
			0% annual rate of growth of production	2.5% rate of growth of production	5% rate of growth of production
coal	930,400 million short tons	6,807 million short toms	137	60	42
Natural gas	6,189 trillion ft^3	104 trillion ft^3	60	37	28
Petroleum	1,317 billion barrels	30.56 billion barrels	43	29	23

Source: Sovacool (2011)

2.6 Energy use and Climate change

Continual access to quality energy infrastructure is fundamental for stable socio-economic development, employment creation, poverty drop and general security of a nation (Oseni, 2012). China have effectively moved about 300 million persons off the poverty line in the last 22 years through enhanced access to energy (Oseni, 2012). A 1% increase in GDP brings about a 1.5% increase in the energy demand (Oh et al. 2010; Saidur, 2009). It is estimated that there will be rise in the per capita income of majority of the present developing countries by 2100 which is predicted to even be higher than the present per capita income of the present developed countries (Nakicenovic et al. 1998), therefore energy demand will increase. Unfortunately more than ten years into the 21st century, source of energy is mainly benched on fossil fuel. Global CO_2 emission from primary energy use is illustrated in Figure 2.6**.** The landmark Intergovernmental Panel on Climate Change (IPCC) report of 2007 put it that the rise in the global atmospheric CO_2 is due to human use of fossil fuel. Some impacts of the climate change may cause further warming leading to more greenhouse gases release, as could be detected, higher temperature cause plants and soils to soak up less carbon from the atmosphere and cause thawing of permafrost releasing large amount of CH_4. This feedback could further aggravate temperature rise by 1-2˚C by the year 2100 (Stern, 2006). The latest report by UN has estimated that 39% of annual human induced emission could be permafrost thawing related amounting to 135 billion tonnes of $C0_2$.

The dynamics of climate change could be seen from a simple illustration. According to United State Energy Information Administration, 50% of 21.3 billion tons of annual global CO_2 emission from burning of fossil fuel is trapped in biosphere. Hence the atmosphere gets warmer with a resultant global temperature increase. A chain of reaction goes on. There is evaporation of water and because water vapour is a greenhouse gas, the atmosphere gets warmer. Ice caps thaw quicker and flow to land and open water. There is further absorption of solar heat by the land and the open water due to their non reflective capacity like the melted ice (Akorede et al 2012). Hence the temperature of land and open water increases further due to the solar effect and more ice melts and this cycle goes round. There could be lop-sided distribution of global rainfall with resultant drought and flood in different regions.

There have been predictions of varied global warming implications in different regions around the world. In coastal areas, rising sea levels may submerge tidal marsh (Craft et al., 2009). Malaysia has a coastline of about 4,800 km, the highest bio-productive area for marine and allied life, fish and wildlife and hold assess for global merchandise and inland trade, port facilities etc (Abdullah, 1992).Consequently with marshes of less than 2m, they may be susceptible to be submerged. Furthermore there could be locale exodus due to displacement of tidal freshwater and brackish marshes by upstream salt marshes. The dwindling marsh area and habitat displacement may result in alteration in the wetlands capability of ecosystem services.

Malaysia average national temperature between 1969 and 2009 has shown that temperature increase in Malaysia would be 0.6-1.2˚C every half a century, with sea level rise of 1.3mm per year (1986-2006) in Tanjung Piai, Johor which is projected to get to global worst of 10mm per year by 2050 (NC2, 2011).

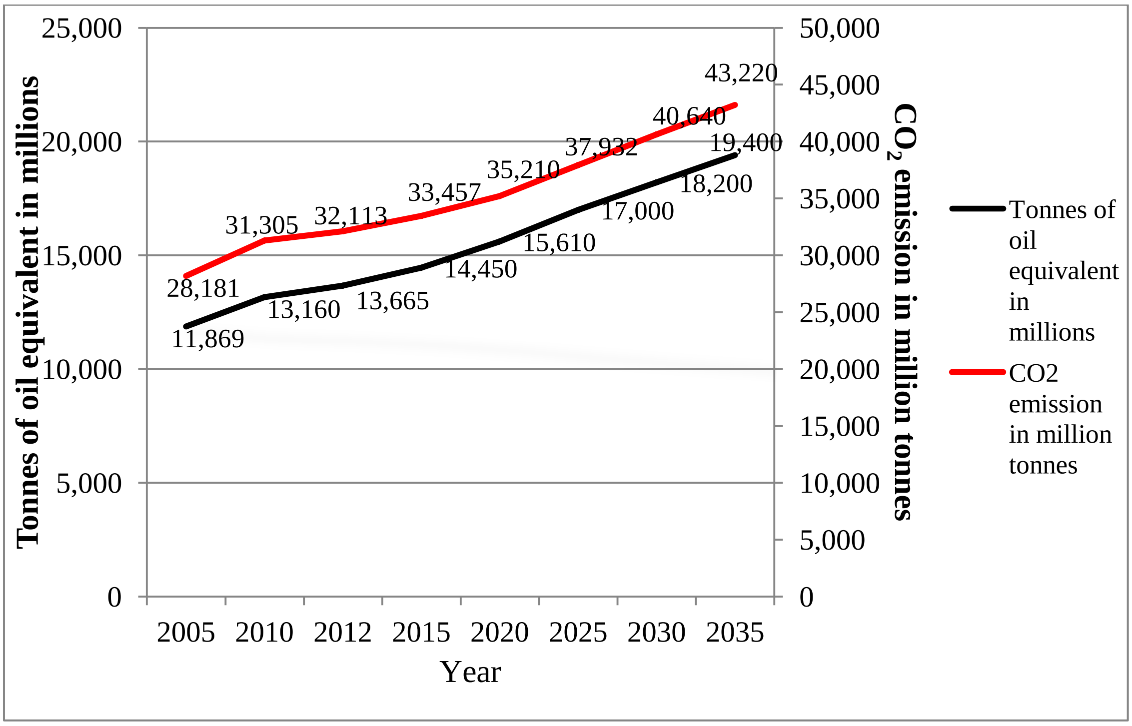

Figure 2.6: Global Primary energy consumption and associated CO_2 emission

Source USEIA (2011)

2.7 Energy Efficiency

It has been predicted that by the year 2060, a global population near 10 billion will have higher median incomes and consume 350% more electricity than current levels (School of Public and Environmental affairs, Indiana University, 2009). Table 2.6 indicates that fossil fuel will be used in decades of years to come. USA and China in 2007 had the highest reserve of coal (BP, 2007). USA had 243 billion tons while China is about 115 billion tons with potential of more than 50 years of reliance on coal.

Renewable energy and Demand Side Management (DSM) which is a measure to reduce electricity consumption as explained further in section 2.12 are among the options necessary for mitigating climate change and enhancing energy security (Brown and Sovacool, 2011). Improving Energy efficiency measures is a very necessary approach to reduce global warming (Zhang et al.2011).

Allcott & Greenstone, (2012) said that different analysis shows energy efficiency offers a win-win opportunity and illustrated it that "If the United States were to make a serious commitment to conservation, it might well consume 30 to 40 percent less energy than it now does, and still enjoy the same or an even higher standard of living . . . ’’

Many works has also followed same trend even after several decades that followed. McKinsey and Co (2009) made similar statement “Energy efficiency offers a vast, low-cost energy resource for the U.S. economy—but only if the nation can craft a comprehensive and innovative approach to unlock it. Significant and persistent barriers will need to be addressed at multiple levels to stimulate demand for energy efficiency and manage its delivery . . . If executed at scale; a holistic approach would yield gross energy savings worth more than $1.2 trillion (RM3.66 trillion), well above the $520 billion (RM1.58 trillion) needed through 2020 for upfront investment in efficiency measures (not including program costs). Such a program is estimated to reduce end-use energy consumption in 2020 by 9.1 quadrillion BTUs, roughly 23 percent of projected demand, potentially abating up to 1.1 gigatons of greenhouse gases annually”.

Table 2.6: Percentage of Net Electricity Generated by Coal in 2005 and estimation for 2030

Coal	2005(%)	2030(%)
USA	49.7	54.2
China	77	84
India	74	65
Japan	30	23
South Korea	41	~ 36
Australia/New Zealand	>70	68
Non-OECD Asia	67.3	72.1
OECD Europe	29.7	22.4
Africa	47	32
Middle East	4.98	3.3
World	41	46

Source: USEIA, 2008

In Malaysia, 13% of overall energy consumption and 48% of electricity consumption is utilized by the building sector (Ministry of Energy, Water and Communications Malaysia, 2006). As part of government effort to spear head energy efficient and conservation practice, a Low Energy Office (LEO) that served as the administrative office of the then Ministry of Energy, Water and Communications (MEWC) now Ministry of Energy, Green Technology and Water became the landmark example (Lau et al. 2009; Oh and Chua, 2010). This building was started in 2002 and commissioned in 2004 with a total air-conditioned area of 19,237m^2, which consumed 45% of the energy, lighting, 21% and equipment 34%. Compared to conventional 275 kWh/m^2 building energy index in Malaysia, the building index was 114 kWh/m^2. The return on investing the energy efficient measures in this building is estimated to be less than 9 years (Lau et al.2009). In 2007, due to the success of the LEO building, the government embarked on a more energy efficient construction of the research office for Malaysian energy centre termed 'Zero energy office ZEO'. The building index design value is about 40kWh/m^2 yearly (UNFCCC, 2008). Part of the renewable energy design incorporated here was Building-Integrated Photo-voltaic (BIPV) panels generating solar electricity for the building consumption during the daytime (Lau et al.2009) The excess energy from the BIPV is fed to the national grid (Pusat Tenaga Malaysia, 2007). This project cost RM 20 million (USD 6.2 million) which was 10% higher than a bench marked building without incorporation of efficient technologies like the BIPV.

2.8 Elements of major energy concern

In the context of this research the focus is on major elements that are responsible for high energy need with high economic and environmental viability on improvement or aspects associated with energy efficiency.

2.8.1 Lighting

Lighting needs to be seriously attended to as it plays a key social, domestic and also industrial role. Thus its illumination at night enables activities and also it is essential where there is inadequacy of natural lighting. Technologies evolution in lighting has been dependent on three aspects of performance, efficiency and cost which could be seen from the progression of common open fire, moving on to usage of kerosene wick and getting to usage of incandescent or fluorescent lighting which are energized by electricity. This progression also applies to the consumers of these lighting technologies, as it is common for people to progress in their use of lighting technologies as their economic strength is increased.

Three types of electric lamps characterize lighting technology exist; incandescent, fluorescent and high-intensity discharges (HID).

Incandescent lamps are lighted by incandescent filaments. This lighting technology is mostly used in residential areas probably due to its cheap initial cost.

Fluorescent light are mainly used in offices. Lighting of fluorescent lamp is by excitation of mercury vapour using electricity (Mahlia et al, 2011). Short wave ultraviolet light results from this excitation and hence resulting in fluorescence thereby producing light. Electrical energy is more efficiently converted by the fluorescent tube more than the incandescent. However in residential homes fluorescent is not widely used probably because of the initial capital cost. However many literature has mentioned that its efficiency in energy utilization offsets the initial investment cost on the lamp (Onaygil and Güler, 2003; Mahlia et al. 2011). For instance the case study of light retrofitting in University of Dar ES Salaam in Tanzania which is discussed further in section 2.12 showed that the initial cost of an incandescent bulb was about RM1 which was about 2,000% less than the compact fluorescent lamp however the fluorescent luminary consume a quarter of energy utilized by the incandescent with an added advantage of 1000% better life span.

In educational buildings, 42% of electricity consumption is by lighting (Figure 2.7) which is second to HVAC in the educational institutions.

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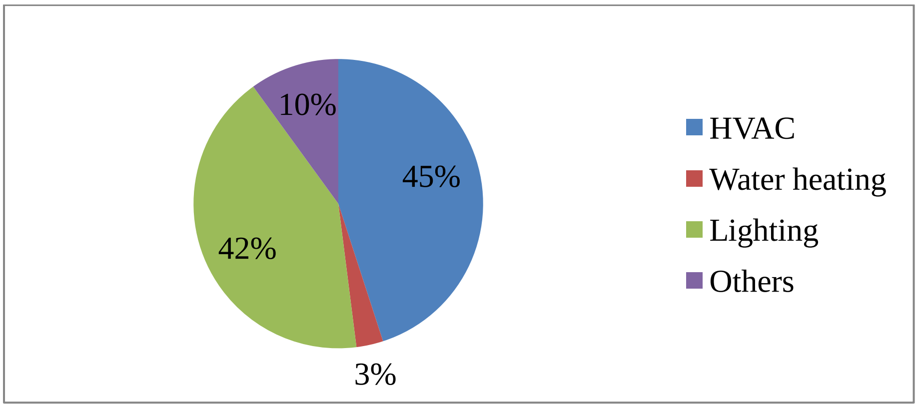


Figure 2.7: Percentage energy used in educational building.

Source: Mahlia et al. (2011)

2.8.2 Lighting retrofit

Lighting retrofitting according to Sustainable Energy Regulation and Policy making for Africa is the replacement of status quo light technology with a new but more efficient light technology. The benefit of retrofitting may manifest at the long-run since it involves more capital cost at project execution stage. Lighting system need to be accurately planned to achieve the needed lighting level while using minimum amount of electricity (Mahlia et al. ,2011) so as to avoid unnecessary expenditure on electricity bills and reduce emissions which could cause climate change. Efficiency of luminaries becomes an important factor in overall energy use.

Hence some electricity end point use equipment such as air conditioners is positively affected by improvements in lighting efficiency. It has been estimated that in large air-conditioned buildings or residences in tropical countries like Malaysia, a kWh of lighting power saved, about 33% of every kWh from the air conditioner will be saved (Benya, 2011). Therefore it is important to integrate lighting retrofitting as measures to improve energy efficiency as this will enhance economic growth and improve environmental quality.

The shapes and sizes of fluorescent tubes, common in education environment are many, however the sizes can be comprehended easily based on the unique coding with every size having a suffice 'T' denoting tubular. There has been new advancement in fluorescent lighting over the standard T8 and T12. T8 and T12 have diameter of 26mm. Mahlia et al.(2011) has carried out a study on light retrofitting in an educational institution and mentioned that lighting is the second highest that consumed electricity and retrofitting with high performance T8 lamp (HPT8) and T5 offer great energy saving though it involved higher investment cost. However he said that T5 could be more costly among the technologies considered but has a potential to save 50% of the energy in lighting as compared to the conventional fluorescent tube.

2.8.3 Heating, Ventilation and Air conditioning (HVAC)

Population growth, enhancement of building services and comfort levels inclusive of increase in time spent inside buildings have lead to increase in energy consumption. Energy use in buildings accounts a big chunk of final energy consumption, amounting to 20-40% in developed countries (Pérez-Lombard et al. 2008, Saidur 2009). The question calls; with the high energy consumption and associated greenhouse emission in the built environment, are we aiming at policies that would build in energy efficiency and conservation strategies?

HVAC are very essential for occupied building. However the mechanism is dependent on the outdoor air condition which will determine whether the air will be heated or cooled before circulation in the occupied building. According to EPA, HVAC refers to the equipment that can provide heating, cooling, filtered outdoor air, and humidity control to maintain comfort conditions in a building. Pérez-Lombard et al. (2008) reported that Instituto para la diversificación Ahorro de la energía (IDAE), Madrid has estimated that the HVAC contribution in the energy use in the non- residential areas is about 48%. However this research concentration shall be in the air-conditioning aspect since heating is more attributed to the temperate region. In modern cities in the tropical regions, air-conditioning of building takes the largest amount of electrical loads (Yik et al 2001). As part of measures by the government to reduce energy consumption, the Government of Malaysia has set a compulsory limit of 24°C for air-conditioners in the offices except for some sensitive places like the laboratories.

One of the most essential aims of HVAC design engineers is maintaining the thermal comfort for occupants of buildings. According to ANSI/ASHRAE 55 2010, thermal comfort is a mindset of conducive status in regard to the thermal environment and could be evaluated subjectively.

Yamtraipat et al.(2005) conducted a study of thermal comfort standard for air-conditioned buildings in hot and humid Thailand and put forward that 26˚C and 50-60% humidity could be taken as the conducive atmosphere for Thailand which was based on 80% acceptability votes.

It has been found that a 1˚Cincrease of thermostat set-point (22˚C to 28˚C) as tabulated in Table 2.7 saves energy of about 6.14% (Yamtraipat et al 2005; Saidur, 2009) and in terms of electricity bill, it saves about 7-10% (Yamtraipat et al 2005).

Table 2.7: Percentage energy associated with thermostat adjustment

Temperature ˚c	Reduction in energy (%)
22	-
23	6
24	12
25	18
26	24

Source: Yamtraipat et al (2005), Saidur, (2009)

2.8.4 Buildings

There is estimation that buildings are worth US$7.5 trillion (RM 22.87 trillion) per year, contributing to around 10 percent of global GDP (Betts and Farrell 2009; UNESCAP, 2012). There is a projection that building will be responsible of almost 35% of global CO_2 emission in 2030 with the major contribution from developing countries, including developing Asia (IPCC, 2007; UNESCAP, 2012). As drivers for more shelter which includes population increases and rise of living conditions in developing countries amplify (UNESCAP, 2012), there is potential for proliferation of more buildings. Hence there is a need for more energy to support the growth. This leads to rise in energy demand and associated rise in embodied GHG emissions.

Filippín (2000) has reported that about 50% of the global CO_2 emissions could be as a result of combustion of fossil fuel in the urban building (buildings in urban areas) systems and that outside the construction part, about 33% of the total energy consumption in 1992 was due to operation in buildings, furthermore that 26% of this amount was from the burning of fossil fuel.

Szokolay (1997) has estimated that buildings are responsible for 40% and 50% of the total energy consumption in US and UK respectively while in Australia its about 26% (Filippín, 2000). In Malaysia 13% of overall energy consumption is utilized by the building sector (Ministry of Energy, Water and Communications Malaysia, 2006). Consequently sustainability of energy is a concern. Aktacir et al (2010) has mentioned that a building of sustainable design is able to save 50% energy. Filippín (2000) has suggested that standardized designs and management practices as well as development of local standard for energy demand and greenhouse emission are essential to improve the energy efficiency of buildings which will contribute to global mitigation of environmental change.

Between 1978-1990, China was able reduce over 30% of its total energy consumption by incorporating simple elementary design and construction technologies (Filippín 2000) like, among other techniques, use of solar panels and added insulations.

It is estimated that about 30% of global CO_2 emission envisioned for year 2020 could be evaded cost-effectively if various technological options are incorporated and benefits from this could be among others; reduction of air pollution, mortality, enhanced social welfare and energy security (Koeppel and Urge-Vorsatz 2007; IPCC 2007). Therefore Malaysia it is not possible for Malaysia to improve on its GHG emission if business as usual continues in its energy sourcing.

Many buildings existing now will still be in use in decades to come. Power (2008) mentioned that in the United Kingdom, the longevity of about 22 million buildings which forms 87% of the existing building will be up to year 2050. Due to the high energy demand in the operation of buildings, efficient measures become essential. This is hampered by the low turnover of the building stock which slows down the energy conservation technologies (Kuckshinrichs, 2010). For instance the Government of UK put a 17.5% VAT on all repairs or reinvestments in building whereas new buildings are VAT free (Power, 2008). Hence more people prefer status quo since new building will consume 4-8 times more resources than refurbishments (Ireland, 2008; Yates, 2006). However some policy measures could help (Kuckshinrichs, 2010), but Government continued subsidy of energy mostly in developing countries has countered this. Subsidy on fossil fuel in developing and emerging economies in 2010 amounted to over $400 billion (RM1.22 trillion) in 2010, over 33% increase in just a year (OECD, 2012). An example could be cited with Malaysia where Government subsidizes the fossil fuel benched energy, hence the true cost of energy use is not paid, and consequently the populace see no importance in going greener.

Saidur (2009) has reported that the Malaysian Energy Centre (PTM) (now known as Malaysia Greentech Corporation) conducted an energy audit on 68 office buildings in 2006 to find among other aspects, age, type of building, gross floor area, occupancy numbers and air-conditioned areas and they found that energy intensity for these buildings in total was 130 kWh/m^2. The result is higher than Japan but lower than in USA which is 121 kWh/m^2 and 293kWh/m^2 respectively (Saidur, 2009) as depicted in Table 2.8.

Table 2.8: Energy intensity for commercial buildings in Malaysia and selected countries

Country	Energy intensity (kWh/m^2)
Malaysia	130
Thailand	154
Japan	121
Shanghai	180
Greece	187
USA	293

Source: Saidur (2009)

New buildings use 400-800% more resources than refurbishments (Ireland, 2008; Yates, 2006), as foremost components of the building mass such as foundation layout, pillars, roof frames etc. are already there and only barely need replacing (Power 2008). Therefore retrofitting becomes essential.

There could be conservation of energy also by retrofitting insulations, replacement of window (Roberts, 2008). Power (2008) suggests that it is highly profitable using tested methods for building renovations like under-floor and solid wall insulation. He has elucidated this using a case study termed 'German Zukunft Haus Pilot Programme 2003-2005' where 915 homes in 34 pre-1978 buildings spread across Germany were upgraded and efficient technologies including as stated above built in. Figure 2.8 point up this. It is seen that the retrofitting of the aged buildings has put them at over 200% more efficient than newly built units with demand for primary energy at just 41kWh/m^2 per annum. This matches the Zero Energy Office in Malaysia.

Furthermore in 2007, the German Government as part of efforts to replicate this success and reduce the nation's energy consumption which is associated in GHG emission is embarking on retrofitting of about 30 million homes built before 1984.Power (2008) mentioned that achieving this target by 2020 will massively contribute to the 40% carbon emission reduction road map of Germany.

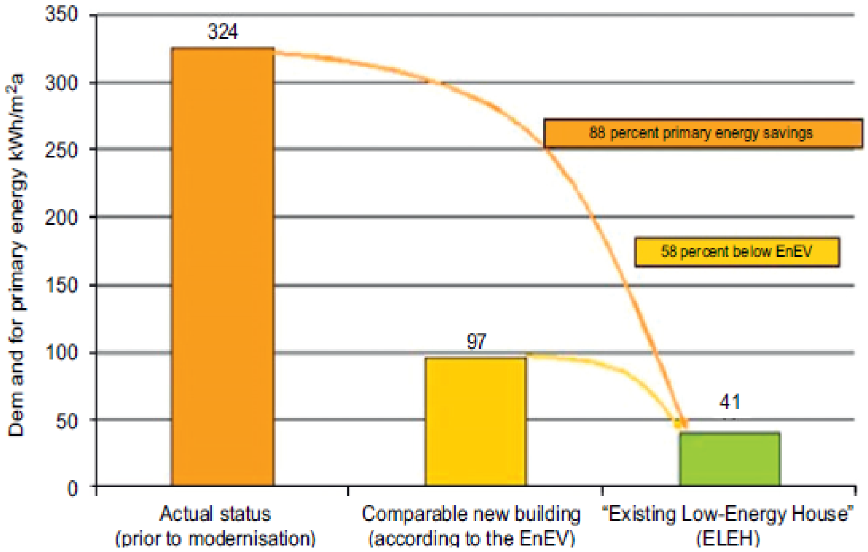


Figure 2.8: Data of energy reduction in the German building retrofitting programme

Source: Power (2008)

2.8.5 Energy code

Energy codes are standards for residential and commercial buildings that set minimum level of energy efficiency thereby solidifying future energy savings at the onset of new construction or renovation. Standards are very essential because it set least amount of requirements for energy efficient design and construction (Iwaro and Mwasha 2010).

Some countries like Singapore, Philippines and Thailand to enhance energy conservation has adopted compulsory building energy performance criteria which serves as part of laws to strengthen building energy conservation, but in Malaysia and Indonesia, building code is on voluntary base (Chirarattananon et al., 2004).

However Malaysian Government through the Public Works Department (PWD) is collaborating with the United Nations Development Program (UNDP) in a program Building Sector Energy Efficiency Project (BSEEP). BSEEP primary goal is reduction of annual emission rate of GHG in Malaysian buildings especially those in the commercial and government sectors (UNDP, 2013). This target is done through the improvement of the energy utilization efficiency, by promoting the energy conservation design of new buildings and by retrofitting to improve efficiency in the operation of existing buildings.

2.9 Waste Management Scenario in Malaysia

Human population explosion especially high rural-urban migration and economic development can lead to increased generation of municipal solid waste (MSW). World Bank estimates the global MSW generation is about 1.3 billion tonnes per year. It is estimated that 70% increase in MSW is eminent in 2025 with rise in GDP, human habits, consumption and local climate.

It has been reported in the 9th Malaysian Plan (9MP) that, the average per capita generation in 2005 was 0.8kg/person/day, an increase of 0.13kg/person/day from 2001 figure. Karak et al. (2012) has stated that generation rates could vary from 0.5-0.8kg/person/day to 1.7kg/person/day in major cities. In Peninsular Malaysia, waste generation has increased from 19,100 tonnes per day in 2006 to 23,000 tonnes in 2008. This could get to 31,000 tonnes per day in 2020 with a 3.6% growth rate (Chua et al.2011). Karak et al. (2012) mentioned that quantification and characterization of the solid waste shown in Table 2.9 is very vital in devising the management scope. This is in line with Zhang et al. (2012) findings that solid waste management requires quick attention mainly in emerging economies like China, South Korea and Malaysia.

In order to manage the municipal waste in Malaysia, three companies are given the concessionaire to collect waste. Environmental Idaman Sdn Bhd handles the northern part of Malaysia, Alam Flora Sdn Bhd; central and eastern part of Malaysia while SWM Environment Sdn Bhd. is responsible for the South of Peninsular (The Star online, July 11, 2011).

Table 2.9: Compilation of municipal waste composition from cross referencing.

Components	2001	2001	2002	2003	2004	2005	2005	2007	2010
Food waste & organic	68.4	32	56.3	37.4	49.3	45	47.5	42	43.5
Mixed plastic	11.8	16	13.1	18.9	9.7	24	-	24.7	25.2
Mixed paper	6.3	29.5	8.2	16.4	17.1	7	18.5	12.9	22.7
Textiles	1.5	3.4	1.3	3.4	-	-	2.13	2.5	0.9
Rubber and leather	0.5	2	0.4	1.3	-	-	-	2.5	-
Wood	0.7	7	1.8	3.7	-	-	4.41	5.7	-
Yard waste	4.6	-	6.9	3.2	-	-	2.72	-	-
Ferrous	2.7	3.7	2.1	2.7	2	6	-	5.3	2.1
Glass	1.4	5.5	1.5	2.6	3.7	3	-	1.8	2.6
Pampers	-	-	-	5.1	-	-	3.81	-	-
others	2.1	1.9	8.4	5.3	18.2	15	21.93	2.6	1.8
Total	100	100	100	100	100	100	100	100	100

Source: Karak et al. 2012

Malaysia is a tropical country with high rainfall. Hence this disassociates the waste composition here from other countries. The Municipal solid waste (MSW) in Malaysia has high moisture content. The moisture content hovers around 52.6% - 66.2% (Hassan et al 2001; Chua et al. 2011). Table 2.9 showcases cross reference from Karak et al.

(2012) on the composition of municipal solid waste in Malaysia. We see that though the composition has changed with time, biodegradable component remains high.

Malaysia MSW recycling rate is about 5% and the waste sector contributed almost 12% of GHG emission in Malaysia in year 2000 (NC2, 2011). The recycling rate is expected to hit 22% by 2020 (Malaysia Ministry of Housing and Local Government, 2008). Therefore Malaysia's waste contribution to GHG may decrease.

The Solid Waste and Public Cleansing Act 672 of 2007 was the spring board which transferred executive management powers of solid waste from Local Authorities to the Federal Government. Under this new status, the Department of National Solid Waste Management and the Solid Waste Management and Public Cleansing Corporation were formed to take charge of waste related issues. The Solid Waste Management and Public Cleansing Corporation is charged with the day to day operation of waste management.

2.9.1 Waste and climate change

Waste contributes 3% of world wide GHG emission (1PCC, 2007) but 12% in Malaysia (NC2, 2011). The difference in scenarios of waste management in regions across the globe could be responsible for the sharp difference, with Malaysia sending more than 90% of daily waste generated comprising about 50% food waste to the landfill, it is apparent to be associated with huge GHG emission and contribute significantly to Malaysia's total GHG emission. As previously mentioned, the effect of the climate change could be regionally felt. The impact of the global warming in Malaysia based on temperature rise of surface air could be in the range of 1.5˚C-2.0˚C by 2050 and Peninsular Malaysia and east part of Sabah could experience a shortage in average annual rainfall while there could be increase in average annual rainfall in other regions (UNEP, 2010). In general, global warming is predicted to affect water resources, agricultural, forestry and biodiversity, coastal and marine and public health sector in Malaysia (Chua et al, 2011).

Organic materials such as food, paper, wood and garden trimmings are some of the constituents of waste. Hence on deposition in a landfill, microbes start to consume the degradable organic carbon (DOC). They consume the carbon content and decomposition starts. Because the landfills are predominantly anaerobic; the microbes responsible for the decomposition contain methane-producing bacteria. Over a period as the microbial community (methanogenic bacteria) gradually decompose the organic matter, there is generation of approximately 50% apiece of methane and carbon dioxide including less than 1% of other trace amounts of gaseous compounds in the landfill (UNEP,2010; Pingoud and Wagner, 2006). These resulted in landfill gas. The largest source of GHG emission from the waste sector is methane emission from the landfill. Bogner et al. (2007) has estimated that methane contributed about 700 Million tonnes carbon dioxide equivalent in 2009. Furthermore he mentioned that the next in the hierarchy of emission from waste is incineration which is estimated to have emitted about 40 million tCO_2e. Landfill emission of CH_4 in Malaysia has increased from 26.4 Million tonnes in 2000 to 31.9 million tonnes in 2007. In year 2000 it was the 4th largest emitter (NC2, 2011). Emission trend as highlighted in Figure 2.9 depicted that landfill contribution increased over 100% as compared to palm oil, domestic and commercial, SMR and latex contribution to GHG with very minimal GHG emission and little comparative increase in GHG emission intensity. Therefore it is crucial to look into GHG emissions from landfill.

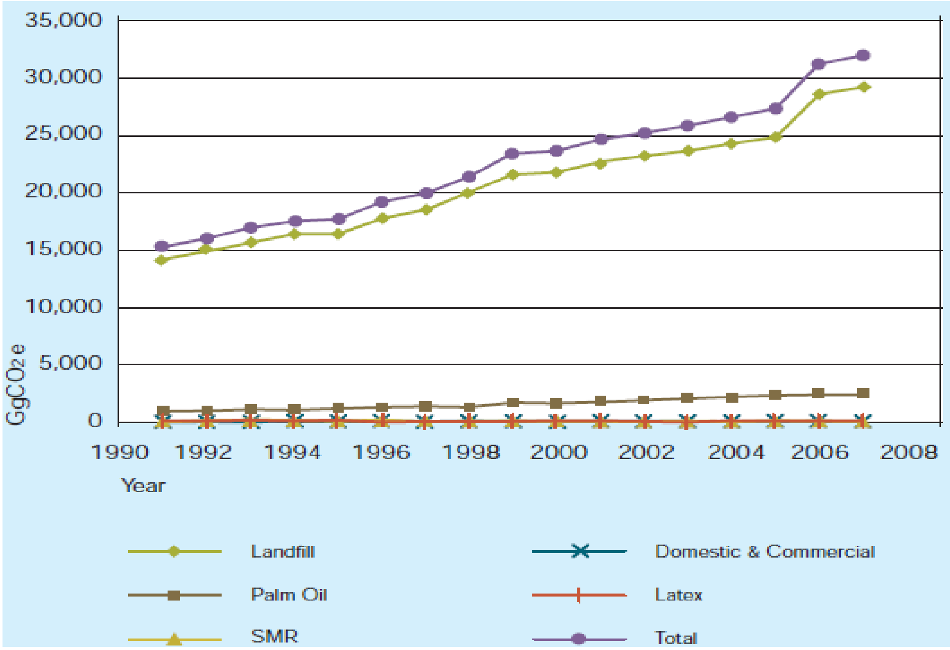


Figure 2.9: Emission for waste sector in Malaysia from 1990 to 2007

Source: (NC2, 2011)

2.10 Carbon Market and Future potential

The carbon market which is benched on ETS, CDM and JI projects was strongly perceived after the adoption of the UNFCCC at the Rio de Janeiro conference in 1992. Initial likely projects starting about 1990 were on carbon offset through forest conservation and reforestation which were to make up for carbon emission by big companies; achieving this through projects in Bolivia, Ecuador and Guatemala (Schellnhuber et al. 2006). Furthermore they highlighted that modern scenario into UNFCCC starting with a pilot programme ‘Activities Implemented Jointly-AIJ’, meant to allow for emission reduction investment in other countries to generate carbon credit. Hence USA and Brazil became the main architects of the carbon trading involving the developing nations in the fight to mitigate climate change. However it came into full limelight at the historic 1997 Kyoto Protocol where world leaders unanimously agreed to draw up an economic incentive based mechanism to tackle the greatest challenge faced by man, climate change. USA signed but did not ratify the protocol while

Australia only ratified it in 2007 (The Sydney Morning Herald, 2007).Under the Kyoto Protocol, three mechanisms as stated earlier are structured to achieve reduction of greenhouse gases.

Europe's Emission Trading Scheme (ETS) is the largest carbon market relative to the number of participants and trading activities. It constitutes 80% of global carbon market (Spash, 2010). The worth of ETS in 2007 was US$51 billion (RM155.55 billion) (European Commission, 2008) and US$80 billion (RM244 billion) in 2008 (Kantner 2008). Carbon trading has turned out to be the major reaction of the global village to the climate change emergency, since the future full potential impact is almost a mirage in the agreed possibility of catastrophe.

There is estimation that demand for emission reductions generated in developing countries could range from 2,156 to 2,706 billion tCO_2e over 2013–2020 (Kossoy 2008; Kossoy & Guigon, 2012). Such demand may be met through offsets generated from CDM and JI projects, as well as new market approaches under the UNFCCC or agreements concluded outside of the multilateral.

Carbon market was negatively affected by the global economic downturn and also the signal of long-term excess supply by the EU Emission Trading Scheme which is the pivot of worldwide carbon market, catalyzed the plunging of the carbon prices (Kossoy & Guigon, 2012). In 2011 the prices plunged further due to the uncertainty surrounding the end of the first commitment period of Kyoto Protocol. Figure 2.11 shows overall CERs prices fell by 27% year on year to about 91 million tCO_2e with same trend for the offset price which fell almost 8% from US$11.8 (RM36) in 2010 to US$10.9 (RM33.25) in 2011. Consequently the CDM market value downgraded by 32% to US$990 million (RM3.02 trillion) (OECD, 2012).

In 2050, global population could be about 9 million, therefore there will be more pressure on natural resources and GHG emission would rise. Prediction is even at a stringent compliance by all parties to the Copenhagen Agreement, yearly GHG emission will strike 49 $GtCO_2e$ by 2010 (UNEP, 2010). Figure 2.10 shows carbon offset will be necessary to reduce global carbon emission equivalent by 18% and 25% in 2020 and 2050 respectively. Carbon market is likely to grow especially with mitigation and adaption cost expected as shown in Figure 2.10. Therefore the carbon market will thrive if we must avert dangerous climate change. However in the face of conflicting reports about CDM performance, much criticism has been on the perceived level of objective achievement of sustainable development. Taiyab (2006) stated that the market favours more of low cost, high volume projects like landfill energy projects at the expense of small community based projects which could have more benefits to the local community and also the capital cost of vying into the CDM and the bureaucratic procedure is only for a few to meet up.

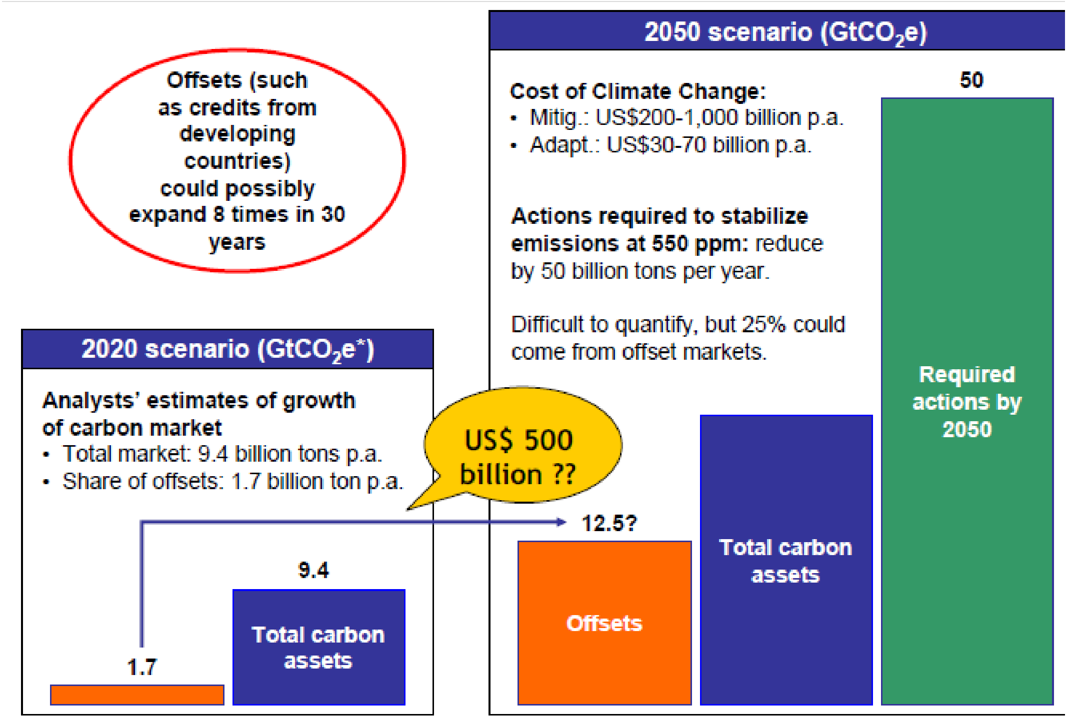


Figure 2.10 Carbon market and climate change economics in year 2020 & 2050

Source: Kossoy, 2008

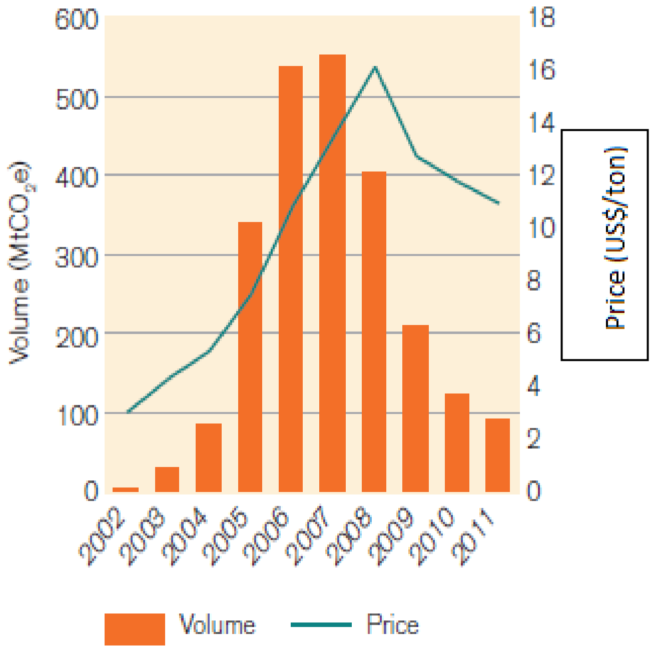


Figure 2.11 Volume and average prices of pre-2013 CER deal since 2002

Source: Kossoy, 2008 &Kossoy & Guigon, 2012

2.11 Low Carbon City Framework as potential for carbon emission reduction

Low carbon economy has started gaining attention in the recent past due to concern about the potential harm from continued business as usual emission of GHG. As sensitivity on the importance of mitigation of the climate change increase; championing the remedial course has expanded from the global level down to cities and even local authorities. Cities in the recent past have attempted to design and implement strategies linked to climate change adaptation and mitigation (Sarah, 2010).

This is even trickling into smaller communities like universities, hence from low carbon cities to low carbon campuses. High ranking institutions are cashing on the issues of climate change to strategize for a better corporate image, thereby gaining more quality students and enhancing their research base. More students are considering sustainability as part of their criteria for choice of university to attend; hence in the UK they look at ‘People and Planet's Green league tables’ to make their choice (Imperial College

London, 2012). People and Planet's Green league administered by a student led network ‘People and Planet’ rank universities by environmental and ethical performance. 13 indicators under Policy and Performance including environmental policy, environmental auditing, curriculum, energy water, carbon emission are used to assess over 140 universities in UK. The assessment is yearly.

In 2006, World Economic Forum's Global University Leaders Forum (GULF) was formed with sustainable campus charter as the guiding principle (MIT, 2012). The charter commits signatory universities to tailor campus operations towards a more energy-efficient and sustainable future. Among the lead universities, about 26 of them that have signed this charter are Harvard University, Carnegie Mellon University, Yale University, Oxford University, Cambridge University, and others in the Americas, Europe, and Asia like National University of Singapore (NUS). By signing this charter, the leaders of these universities have committed to enhance their green initiatives locally and to share information worldwide with emphasis on 3 key environmental responsible goals to:

Improving the design and functioning of campus facilities, especially buildings, integrating the issue of sustainability into institution-wide planning and working towards developing the university as a living laboratory, with students and faculty using their home institutions as research platforms to explore energy conservation, efficient materials use, improved transportation, and related issues.

These universities have been at the forefront of initiating and implementing strategies and policies aimed at low carbon campus status. Some of the initiatives on course are worthy of mention. Among activities conducted, MIT, Yale University and Imperial College are highlighted.

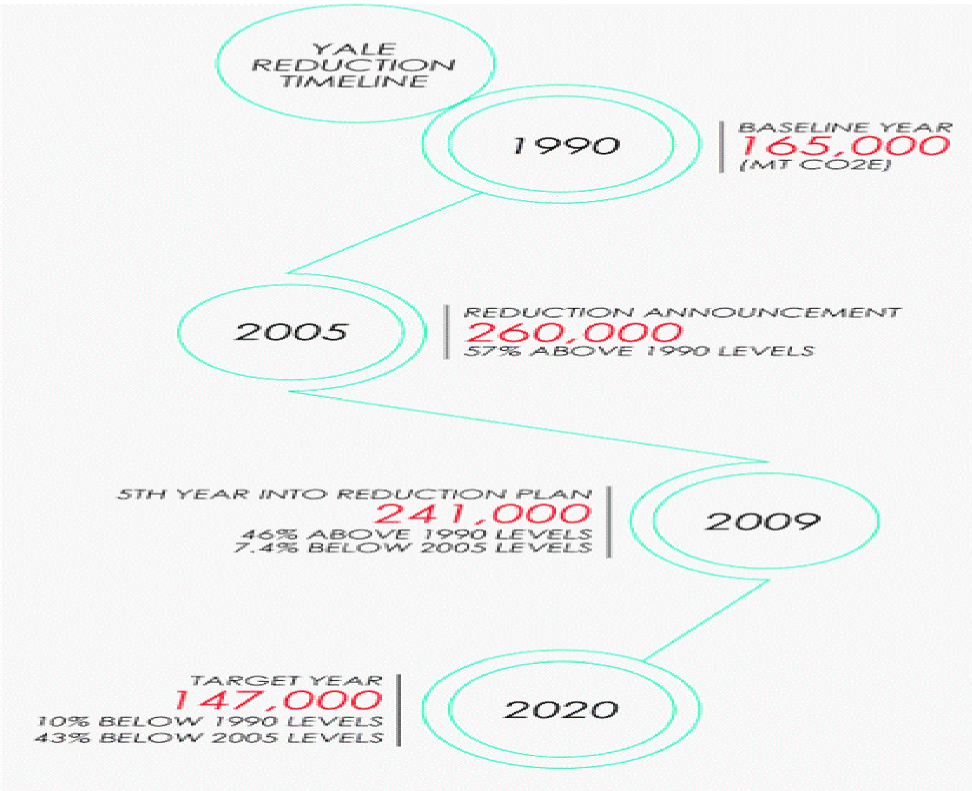


Figure2.12: Yale University's carbon reduction plan

MIT has strategized for this by formation of MIT energy initiative (MITEI) in 2006 (MIT, 2012). The aims of this project include reducing MIT energy consumption and the associated GHG emission in an economically viable way, using the school as base for research innovation. A taskforce incorporating faculty members from five academic schools, representatives from key administrative offices and also undergraduate and graduate students make up the engine base for collaborative research and strategy for sustainable energy practices and energy efficiency in this institution. It is also worthy of mention that a comprehensive carbon footprint was completed in 2003 prior to this which catalyzed the springing of the Campus energy initiative. MIT has reported that this synergy has been saving millions of dollars in operating budgets.

Yale University has positioned itself by forming a task force in the fall of 2004, just like in the MIT's case, academic and non academic staff and also students are incorporated in this taskforce. They develop strategies and recommendations for policies that will lead to transition to a low carbon campus, by especially reduction of energy demand and associated greenhouse gas emission. The ambitious plan by Yale University for transition to a low carbon campus by year 2020 is captured in fig 2.12. A positive result is seen as at 2009.

Imperial College London is also one of the high ranking universities that have developed sustainable track and set a target of 20% CO_2 reduction from its buildings, owned fleet, waste and water in August 2014 as against 2008/9 level (Imperial College, London, 2012).

Kai (2012) reviewed sustainable campus approach of 2358 (2010 figure) universities in China. Most of the schools have established recycling system for material and energy recovery; optimizing energy consumption and minimizing pollution. Some have applied green technologies like solar street lamps, solar water heater etc. There are restriction of motor vehicles in most campuses so as to reduce emissions and noise pollution. In Guanghou University bicycle rental is free within an hour to reduce emissions.

Poyyamoli (2012) has studied campus sustainability in India. The study established that only a few out of the 504 universities in India (2011 figure) has established sustainable development programmes. Universities like Pondicherry, Hyderbad and Teri has established renewable energy (solar systems), integrated solid waste management, water conservation and water-water recycling. Feasibility abides for UM to take advantage.

2.12 Key Performance Index (KPI) and Demand Side Management (DSM) as elements of Sustainability

KPI has been described as financial and non-financial indicators used by establishments to estimate and solidify how successful they are, projecting long lasting objectives and successful feasibility of this is hinged on well-defined and regulated processes within the establishment (Velimirovic et al 2011). Parmenter (2010) has defined it as a set of measures that focuses on those aspects of organizational performance that are the most critical for the current and future success of the organisation. Therefore Key performance indicators should be a pivotal platform that enhances organisations to strategically position their activities to achieve set goals. In the context of this study which is benched on energy use and waste management, key performance indicators here should incorporate tools and measures that will enhance identification of key issue against minimal energy use and proper waste management. This should be a continual process as there is no perfect system.

On the other hand according to Sustainable Energy Regulation and Policymaking for Africa: Demand Side Management module 14, DSM is a means used for reduction of peak electricity demand which will reduce the rate at which investment are needed for further capacity in generation, transmission and distribution networks. DSM represents a revolutionary approach to planning electricity utilities (Gellings and Chamberlin, 1987) and Strbac (2008) documented that the prospect of increasing the efficiency of system operation and the existing investment in the generation and transport of electricity has been the key driver for introducing DSM programmes.

Consequently KPI and DSM are intrinsically related as KPI will lead an information base for input of DSM. Hence evaluation follows to access and measure the performance of establishments from available performance indicator information.

KPI and DSM correlates further looking at the benefits that exist with their implementation in an organisation. KPI leads by identification of key issues which is the basis for any problem resolution. Auditing could be a bridge between them where it assesses and evaluates the KPI identified issues, thereby making necessary adjustments through DSM to achieve higher efficiency. The integration of KPI and DSM will reduce dependency on expensive fuel import, reduction of energy bills and limit dangerous emission to the environment. A case study documented by Sustainable Energy Regulation and Policy making for Africa in Demand Side Management module14 showcases benefits of KPI and DSM. University of Dar ES Salaam in Tanzania electricity bill was rising and had an average monthly bill of $78,640 (RM239,852) which was considered high based on the size and capacity of the institution. A study team was commissioned in 2006 to look into ways for energy reduction and the findings revealed increasing population, installed facilities and inefficiencies of the lighting technology including the fluorescent lamps were responsible. Retrofitting was carried out replacing the incandescent and inefficient fluorescent lighting technology with compact fluorescent bulbs and this resulted to annual electricity saving of 421 MW and associated bill reduction of $48,167 (RM146, 909). Furthermore it was also documented that University Zambia’s energy bill was rising and it owed $ 1 million (RM 3.05 million) in electricity bill. Hence an energy committee was formed to integrate energy efficiency; the initial action undertaken was evaluation of energy consumption in the 52 hostels holding 124 students each and also water pumping systems using ‘clamp-on meters’ which served as KPI. Consequently among other things done were replacement of inefficient fluorescent and incandescent light, installation of automatic switch lights and stringent regulation of types and number of electrical appliances. The energy situation has drastically improved.

In waste management KPI and DSM will help for better practices hence there will be reduction of waste related emissions. Therefore KPI and DSM should be an integral part of operation of any institution as case studies show a win-win situation.

CHAPTER 3

3.0 METHODOLOGY

3.1 Introduction

This chapter describes the methods used in this study including the major components of the research; the methodological framework comprises literature review, observation, on-site visits and surveys, measurements, interviews, questionnaire and analysis of data.

Baseline data on University of Malaya energy use and waste management situation is made available by JPPHB, Zero Waste Campaign and UMCARES.

This piece of work will be a pilot project which could be a base for initiating the carbon footprint of UM. This could also help to look at the future potential in entering the carbon market. Malaysia is still a developing country and eligible for CDM projects.

In order to conduct this work, it involves 3 phases approach, namely: Phase 1; Primary and secondary data collection for energy consumption and biodegradable waste generation. Phase 2; data analysis to calculate carbon equivalent emission and in Phase 3; Specific case study conducted for Main library building to showcase CDM potential.

Primary and secondary data are essential for this study. The primary data collected are: electricity consumption information from year 2007-2012, monthly expenditure for the energy, waste generation in the campus, the number of buildings and the total floor area both for the air-conditioned and non-air-conditioned areas. This forms the fulcrum of the research.

Based on the fact that a salient but important underlining factor in this research is to partly start documentation of carbon footprint of University Malaya, the calculation of the GHG emission has been done manually incorporating IPCC guidelines and some information from literature.

University of Malaya has been appointed as one of the five pilot centres in Malaysia for the Low Carbon Campus Framework (LCCF). To this effect, on October 13, 2012; a Memorandum of Understanding (MOU) was signed between the institution and the Ministry of Green Technology, Energy and Water. Hence the relevance of this thesis since it will be important in championing a sustainable approach towards building a road map for low carbon campus. It will also go further to look at the economic incentive that could be accruable to University of Malaya through better positioned demand side management strategy of the energy consumption and waste management which are all feasible projects in CDM.

3.2 Methodologies for the specific objectives:

1: To determine energy consumption and ascertain waste management practices in UM.

To achieve this objective, data provided by JPPHB, ZWC and UMCARES, on-site visits and interviews of the relevant stakeholders mainly JPPHB is very essential. Questionnaires are used to confirm previous works. The data would be evaluated and determined.

2. To estimate the greenhouse gases emission from University of Malaya related to energy consumption and waste management practices in correlation with CDM.

The estimation of GHG emission associated with energy consumption in University of Malaya will be from a lifecycle approach. This calculation would embrace type of power plants, share of each of the power plants in generation of electricity utilized in UM, types of fuel used by each of these power plants, contribution of each fuel in the power plants and emission factor of each type of fuel and waste energy in the electricity transmission. The work of Shekarchian et al. (2011) is integrated in achieving this objective (Tables 3.1 and 3.2). However some of the data like composition of fuel consumption in power plants for year 2009 henceforth has been conservatively worked out based on the percentage contribution of the various fuels to the energy mix. This is because the data on the composition of fuel consumption in power plants are not available for the period. Also IPCC guideline is incorporated including literature research from UNFCCC website to align with CDM. The emission in the waste part shall be quantified incorporating literature research and similar case studies.

Table 3.1: Electricity Generation (GWH) for various type of power plant from 1980- 2008.

Year	**Conventional thermal (coal)**	**Conventional thermal (oil/ gas)**	**Gas turbine**	**Combined cycle**	**Diesel engine**	**Total**
1980	0.0	6430.8	303.8	0.0	304.5	8165
1981	0.0	6797.4	259.4	0.0	300.2	8780
1982	0.0	7665.2	288.4	0.0	335.1	9506
1983	0.0	8406.6	354.2	0.0	393.0	10,630
1984	0.0	8192.6	357.2	0.0	251.9	11,614
1985	0.0	7433.2	777.4	1097.1	313.1	12,624
1986	0.0	6832.4	741.3	2062.4	237.9	13,515
1987	0.0	8104.3	271.6	2503.5	94.9	14,645
1988	71.8	7309.8	222.3	3865.8	139.3	16,195
1989	1999.0	7356.1	50.3	3591.6	85.3	18,139
1990	2300.0	8550.0	51.3	4321.0	102.6	21,328
1991	3550.0	9450.0	789.0	5432.0	151.6	25,724
1992	4700.0	10,300.00	1043.0	6178.0	242.7	29,469
1993	5982.0	11,000.00	1972.0	6689.0	438.9	33,469
1994	6692.0	12,500.0	3221.0	6777.0	671.5	37,479
1995	7732.0	13,150.0	4321.0	7222.0	789.3	41,317
1996	8923.0	14,100.0	5198.0	7730.0	996.9	45,173
1997	9982.0	15,300.0	6322.0	8612.0	1276.9	49,837
1998	11,123.0	15,900.0	8431.0	9821.0	1441.5	55,188
1999	12,451.0	15,600.0	10,132.0	11,22,1.0	1673.9	59,339
2000	7809.4	4401.4	12,9540.8	40,540.8	1665.7	70,220
2001	14,764.6	4251.5	14,075.7	40,638.5	1718.4	69,855
2002	21,700.3	2945.0	12,632.6	31,155.4	1395.0	77,501
2003	15,409.9	5438.8	18,9534.4	32,138.4	1895.3	82,406
2004	20,938.1	37064.9	6860.6	12,741.1	2049.3	89,098
2005	17,659.6	3914.2	21,291.8	36,866.7	1729.5	91,029
2006	21,719.8	4101.6	15,194.5	40,736.3	1771.1	93,218
2007	28,675.0	3951.7	16,313.3	40,834.0	1823.8	101,325
2008	29,624.8	4020.5	17,245.9	42,532.8	1904.4	105,803

Source: Shekarchian et al. 2011.

Table3.2: Composition of fuel consumption (Mm^3 and ton) in power from 1998- 2008

Year	Fuel type	Steam turbine	Gas turbine	Combined cycle	Diesel	Total
1998	Coal (kton)	1.902033	-	-	-	1.902033
	Natural gas	-	626.5117	735.46963	-	1361.9808
	Fuel oil	1.50891	-	-	-	1.50891
	Diesel		-	-	0.1245456	0.1245456
1999	Coal (kton)	2.129121	-	-	-	2.129121
	Natural gas	-	915.27499	1032.1186	-	1947.3936
	Fuel oil	1.48044	-	-	0.144625	1.48044
	Diesel		-	-	-	0.144625
2000	Coal (kton)	2.99	-	-	-	2.99
	Natural gas	6286.38	2793.94	3221.59	-	12,301.91
	Fuel oil	0.60	-	-	-	0.60
	Diesel	-	0.18	-	0.02	0.21
2001	Coal (kton)	3.97	-	-	-	3.97
	Natural gas	6192.20	2796.00	3674.33	-	12,662.53
	Fuel oil	0.75	-	-	-	0.75
	Diesel	-	0.28	-	0.04	0.32
2002	Coal (kton)	5.07	-	-	-	5.07
	Natural gas	6175.32	2844.30	4198.00	-	13,217.62
	Fuel oil	1.39	-	-	0.06	1.40
	Diesel	-	0.47	-		0.53
2003	Coal (kton)	8.18	-	-	-	8.18
	Natural gas	3351.72	3047.02	5166.69	-	11,565.43
	Fuel oil	0.39	-	-	-	0.39
	Diesel	-	0.25	-	0.03	0.28
2004	Coal (kton)	10.61	-	-	-	10.61
	Natural gas	8365.17	989.43	1837.53	-	11,192.10
	Fuel oil	0.27	-	-	-	0.27
	Diesel	-	0.23	-	0.07	0.30
2005	Coal (kton)	10.99	-	-	-	10.99
	Natural gas	3503.99	3474.42	5987.83	-	12,966.24
	Fuel oil	0.20	-	-	-	0.20
	Diesel	-	0.41	-	0.03	0.44
2006	Coal (kton)	11.89	-	-	-	11.89
	Natural gas	4133.84	2432.55	6521.62	-	13,088.01
	Fuel oil	0.17	-	-	0.07	0.17
	Diesel	-	-	-	-	0.69
2007	Coal (kton)	14.93	-	-	-	14.94
	Natural gas	4784.99	2392.50	5988.67	-	13,166.16
	Fuel oil	0.20	-	-	-	0.20
	Diesel	-	0.31	-	0.03	0.34
2008	Coal (kton)	16.09	-	-	-	16.09
	Natural gas	5220.16	2675.74	5599.07	-	14,494.98
	Fuel oil	0.17	-	-	-	0.17
	Diesel	-	0.29	-	0.03	0.32

Source: Shekarchian et al. 2011

The emission factors incorporated in this study has been used since other writers have used them in working on Malaysia case studies. Also there has not been any comprehensive emission factors published Malaysia Greentech Corporation.

3. To evaluate the eligibility of UM for CDM

This objective will be achieved by adhering to the conditions for eligibility as in the Malaysia CDM handbook in correlation UNFCCC. Furthermore we shall look at information about existing projects that have already applied the methodologies through UNFCCC website.

4. To estimate the potential environmental benefit and also economic benefit of greenhouse through certified emission reduction.

Literature research, baseline line data, results from surveys and assessments shall be integrated with CDM methodologies: AMS 11.N/Version 01.0 approved methodology for demand-side energy efficiency activities for installation of energy efficient lighting and/or controls in building and AMS-111.AO./Version 01CDM: approved methodology for methane recovery through controlled anaerobic digestion. A case study of the University of Malaya's main library is conducted in build up to achieve this objective. Current and projected future price values of CER and energy rate shall be inputted. Results from achieving objective 2 and 3 will be influential in achieving objective 4.

CHAPTER 4

4.0 RESULTS AND DISCUSSION

4.1 Introduction

This chapter documents and discusses the results of electricity consumption and waste management practices in University of Malaya. The estimated greenhouse gas due to the electricity consumption and waste management practices will also be discussed here and finally the eligibility of the institution for CDM assessment and the potential benefits of the reduction of greenhouse gases from electricity and waste situation are harnessed as well.

4.2 Determination of energy consumption and ascertaining waste (organic) management practices in University of Malaya

Tables 4.1 to 4.5 show the electricity consumption details provided by JPPHB for 60 months from January, 2007 to December, 2011. The rate of charge per KWh of electricity consumption is also shown. It could be seen that the electricity tariff has changed 4 times within the period with an increase of almost 35% at the end of 2011 as against RM0.234 which was increased after June 2008. It could also be deduced from the tables that generally the consumption pattern varies during certain period. During the period of February, June and December of 2007 -2010 (highlighted in green), the quantity of consumption is less than the other months in the year probably due to students' semester break where many of the students were not around. However in the 2011 period, the pattern has changed with September to December been about the highest period of consumption because this year the Malaysian Government had changed the academic calendar to synchronize with the European system, so a new academic section commenced in September. December 2011 figure as compared to other months stood at a record high as compared to the figures of same months in previous years possibly due to the fact that students were in the peak of examination preparation hence they consume more electricity due to extended study period.

Table 4.1 Electricity use in UM main campus (2007)

Month	Consumption (KWh)	Rate (RM)	Max Demand (KWh)	Rate (RM)	Total bill after 10% discount (RM)
Jan-07	6,263,961.00	0.234	18,185.00	19.50	1,638,336.94
Feb-07	5,250,423.00	0.234	17,941.00	19.50	1,420,603.63
Mar-07	6,781,967.00	0.234	19,102.00	19.50	1,763,522.35
Apr-07	5,972,777.00	0.234	17,723.00	19.50	1,568,905.49
May-07	5,622,615.00	0.234	15,711.00	19.50	1,459,850.77
Jun-07	5,622,615.00	0.234	15,713.00	19.50	1,459,885.87
Jul-07	5,622,615.00	0.234	18,567.00	19.50	1,509,973.57
Aug-07	6,699,706.00	0.234	18,700.00	19.50	1,739,143.08
Sep-07	6,522,597.00	0.234	18,647.00	19.50	1,700,913.78
Oct-07	5,588,241.00	0.234	18,091.00	19.50	1,494,380.60
Nov-07	5,662,439.00	0.234	15,536.00	19.50	1,465,166.45
Dec-07	5,116,970.00	0.234	16,386.00	19.50	1,365,208.18

Table 4.2 Electricity use in UM main campus (2008)

Month	Consumption (KWh)	Rate	Max Demand (KWh)	Rate	Total bill after 10% discount (RM)
Jan-08	6,319,143.00	0.234	18,390.00	19.50	1,653,556.02
Feb-08	5,739,516.00	0.234	18,337.00	19.50	1,530,556.42
Mar-08	6,413,342.00	0.234	18,488.00	19.50	1,675,114.23
Apr-08	6,430,288.00	0.234	18,660.00	19.50	1,681,701.65
May-08	5,867,043.00	0.234	16,854.00	19.50	1,531,386.96
Jun-08	5,450,237.00	0.234	15,847.00	19.50	1,425,934.76
Jul-08	6,625,358.00	0.296	18,751.00	24.600	2,180,142.51
Aug-08	6,481,912.00	0.296	19,079.00	24.600	2,149,190.42
Sep-08	5,912,520.00	0.296	17,786.00	24.600	1,968,877.37
Oct-08	5,952,164.00	0.296	17,704.00	24.600	1,977,623.05
Nov-08	5,750,352.00	0.296	16,734.00	24.600	1,902,385.07
Dec-08	5,244,557.00	0.296	15,954.00	24.600	1,750,371.54

Table 4.3 Electricity use in UM main campus (2009)

Month	Consumption (KWh)	Rate(RM)	Max Demand (KWh)	Rate(RM)	Total bill after 10% discount (RM)
Jan-09	5,665,663.00	0.296	17,564.00	24.600	1,897,933.18
Feb-09	5,676,227.00	0.296	19,148.00	24.600	1,936,083.59
Mar-09	6,614,802.00	0.288	19,111.00	23.930	2,126,150.29
Apr-09	6,636,866.00	0.288	18,653.00	23.930	2,121,746.13
May-09	5,974,287.00	0.288	16,881.00	23.930	1,912,101.29
Jun-09	5,750,205.00	0.288	16,443.00	23.930	1,844,586.03
Jul-09	6,706,469.00	0.288	18,701.00	23.930	2,141,080.20
Aug-09	6,402,257.00	0.288	19,295.00	23.930	2,075,021.43
Sep-09	5,595,287.00	0.288	18,324.00	23.930	1,844,942.38
Oct-09	6,745,121.00	0.288	18,375.00	23.930	2,144,077.74
Nov-09	5,505,244.00	0.288	16,978.00	23.930	1,792,614.43
Dec-09	5,737,224.00	0.288	16,804.00	23.930	1,848,996.21

Table 4.4 Electricity use in UM main campus (2010)

Month	Consumption (KWh)	Rate (RM)	Max Demand (KWh)	Rate(RM)	Total bill after 10% discount (RM)
Jan-10	6,402,990.00	0.288	18,715.00	23.930	2,083,347.16
Feb-10	5,764,570.00	0.288	20,147.00	23.930	1,947,363.31
Mar-10	7,503,540.00	0.288	20,329.00	23.930	2,406,570.67
Apr-10	6,879,008.00	0.288	19,581.00	23.930	2,226,802.42
May-10	6,169,052.00	0.288	17,575.00	23.930	1,997,306.36
Jun-10	5,899,074.00	0.288	16,561.00	23.930	1,904,571.38
Jul-10	6,596,986.00	0.288	19,230.00	23.930	2,145,336.23
Aug-10	6,781,763.00	0.288	19,420.00	23.930	2,197,842.32
Sep-10	5,418,823.00	0.288	19,723.00	23.930	1,825,874.13
Oct-10	6,835,995.00	0.288	19,166.00	23.930	2,206,514.73
Nov-10	5,729,879.00	0.288	18,745.00	23.930	1,864,279.92
Dec-10	5,780,791.00	0.288	16,599.00	23.930	1,874,432.43

Table 4.5 Electricity use in UM main campus (2011)

Month	Consumption (KWh)	Rate (RM)	Max Demand (KWh)	Rate (RM)	New Energy fund tax	Total bill after 10% discount (RM)
Jan-11	6,170,929.00	0.288	18,593.00	23.930		1,999,942.24
Feb-11	5,573,081.00	0.288	19,824.00	23.930		1,871,492.08
Mar-11	6,964,813.00	0.288	19,695.00	23.930		2,229,450.74
Apr-11	6,590,260.00	0.288	19,428.00	23.930		2,126,616.23
May-11	6,231,869.00	0.288	17,501.00	23.930		1,992,219.48
Jun-11	6,085,579.00	0.312	16,665.00	25.900		2,097,291.73
Jul-11	6,145,705.00	0.312	17,706.00	25.900		2,138,440.82
Aug-11	5,586,381.00	0.312	16,262.00	25.900		1,947,723.00
Sep-11	6,526,857.00	0.312	20,953.00	25.900		2,321,155.88
Oct-11	7,088,452.00	0.312	20,940.00	25.900		2,478,548.72
Nov-11	6,364,471.00	0.312	18,976.00	25.900		2,229,474.02
Dec-11	6,699,309.00	0.312	19,099.00	25.900	23,263.64	2,349,627.29

4.3 Source of electricity

University of Malaya's electricity consumption is sourced from the national grid which is managed by Tenaga Nasional Berhad (TNB), the largest electricity utility in Malaysia. It must be reiterated that the primary energy source utilized by the power plants that supplies the grid is about 90% fossil, hence University of Malaya contributes to the electricity load on the grid vis-a vis greenhouse gas emission.

4.4 Transmission and Distribution

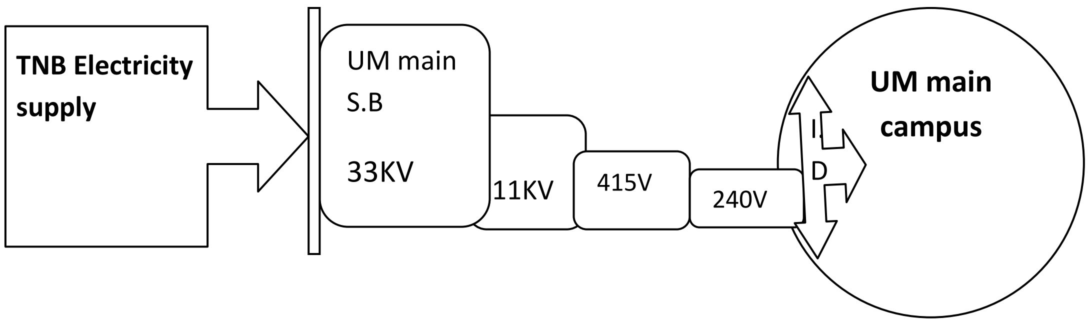


Figure 4.1: Transmission and Distribution of electricity in University Malaya.

TNB supplies University of Malaya electricity through a 33kv line. The modus operandi is elaborated in Figure 4.1. At the point of receipt of this power is called the bulk meter which is the main switch board (S.B). JPPHB at this point will have to step it down to 240v before internal distribution (I.D) to the University community. All the residential colleges except 9th Residential College (supplied directly by TNB since the residential college is outside the campus), the cafeteria all have dedicated meters and pay their own bills based on JPPHB charge rate since they are considered as autonomous and revenue generators. Appendice A- I show the disparity between TNB charge on University Malaya and JPPHB charge on the residential colleges.

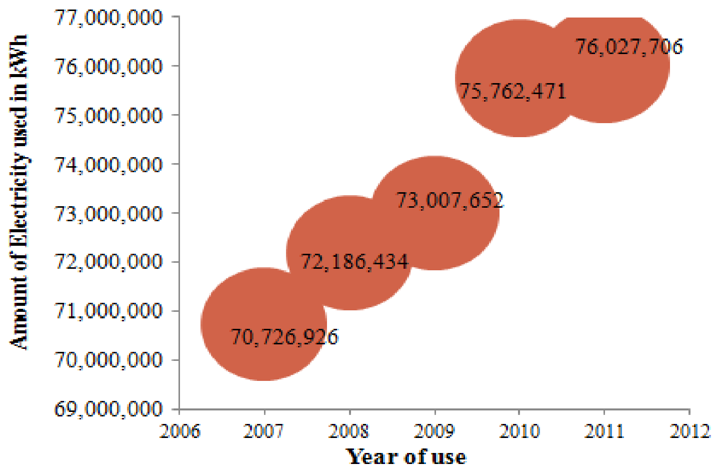


Figure 4.2: Electricity Consumption trend in University of Malaya (2007-2011)

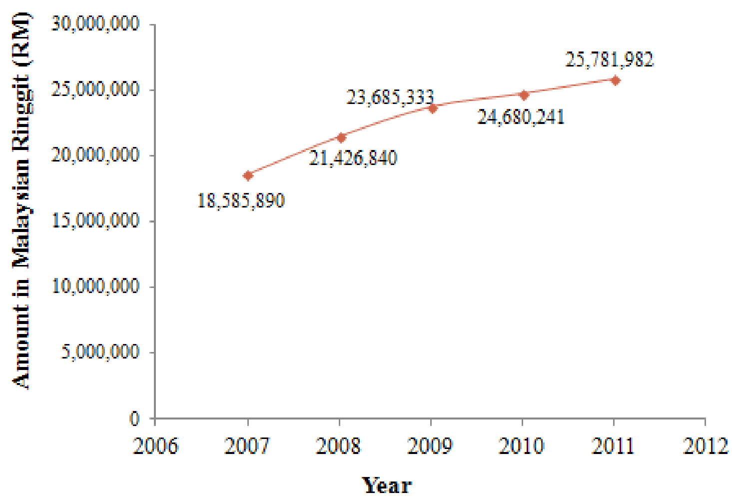


Figure 4.3: Expenditure on electricity in University of Malaya (2007-2011)

Figure 4.2 illustrates the summation from Table 4.1- 4.5 of electricity consumption in the University of Malaya main campus. It has been on the rise increasing by 7.5% at the end of 2011 as against 2007 amount. It shows that about 370,000MW of energy has been directly consumed by the institution over a period of five years with total direct expenditure of about RM 115million after a 10% discount. However during the year 2011, increase in electricity consumption was reduced by more than nine times over increase in 2010 figure over 2009. This could be due to implementation of government new regulation of setting non sensitive offices thermal condition at 24˚C. Table 4.8 indicates an increase of 4138MWh of electricity consumption over 2011. This quantum leap could be due to the commissioning of new buildings including the Chancellery office and the University's Research and Development building with total floor areas 204,440 ft^2 and 164,929.28 ft^2 respectively.

The average per capita electricity consumption in UM is about 2.65MW per year. This is lower than the country's average of about 3.7MW, yet the lifecycle implication of the per capita emission is enormous as would be shown later in the chapter. The increase in the trend of energy use may be associated with the population increase and increase in the number of existing buildings and also some unsustainable use of the electricity. Figure 4.4a-d shows some of the inefficiencies in the energy management in the university. Figure 4.4a and 4.4c show lights around the faculty of Law and main gate are put on when the natural daylight intensity was still good enough. This outlays the fact that there is no automated system that could detect the appropriate light intensity necessary for the lights to come on; instead it may be operating on timer. Figure 4.4b labels 4^{th} floor of the main library as over lighted; the measured intensity was about 290lx which was 16% more than the ANSI recommended intensity of 250lx. In the survey it was found out that there are no dedicated meters in the respective

Departments/Faculties or Institutes which could help to tie down energy consumption to specific areas. This is an issue as it makes it difficult for benchmarking so as to build in measures for a more sustainable consumption.

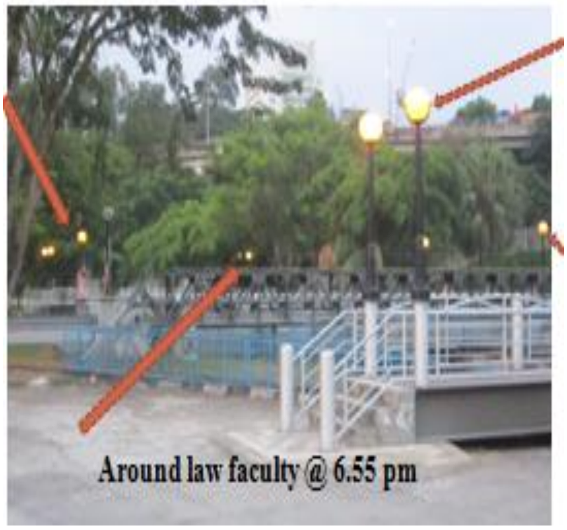


Figure 4.4a

Figure 4.4b

Figure 4.4c

Figure 4.4d

Figure 4.4a-d: Some inefficient use of energy in University of Malaya.

There are 53 carrels (private cubicles for study) in the main library, each with a vent for the air conditioning. Over 90% of the vents in the carrels are covered with papers as shown in Figure 4.4d, probably by students who use the carrels apparently because it is too cold in there. In an educational institution, over 85% of total energy consumed is by lighting and HVAC (Mahlia, 2011). Apparently with rate of consumption affected by thermal interaction of lighting and air conditioning; it could offer an avenue for economic and environmental gain if adequately harnessed.

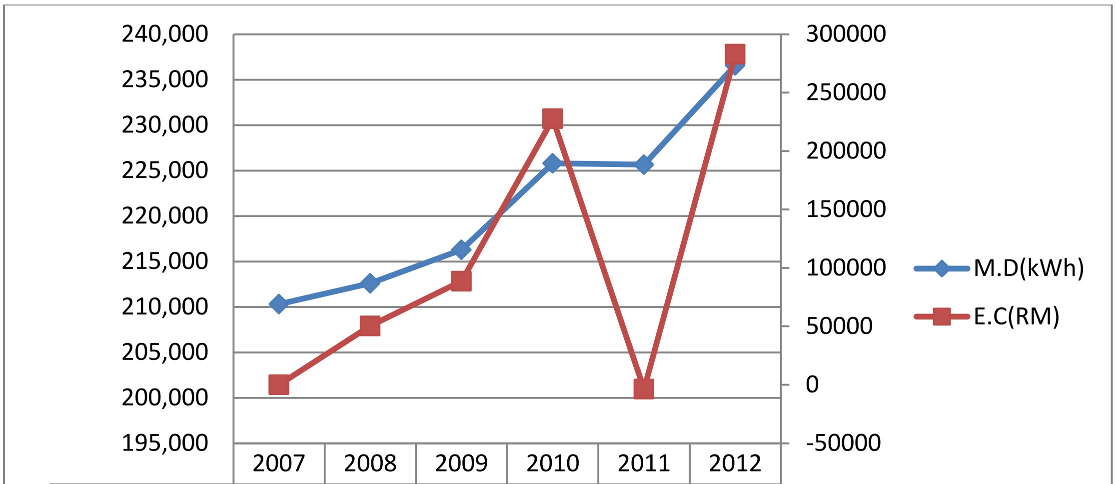
4.5 Interactive relationship of lighting and air conditioning

It has been estimated that in large air-conditioned buildings or residences in tropical countries like Malaysia, a kWh of electricity saved from lighting could result in 0.33kWh saving from the air conditioner (Benya, 2011).UNFCCC methodology AMS 11.N/Version 01.0 demonstrates this trend where Thermal Interactive effect (TIF) is considered under the Demand-Side energy efficiency activities for installation of energy efficient lighting and/or controls in buildings. TIF in this context is the interactive effect of the lighting system on the operational consumption of the air conditioners.

Energy saved from lighting has a positive interaction on the air conditioner energy consumption (Benya, 2011).

In the tropics like in Malaysia TIF will be an added advantage, hence it is put into context in calculation of the emission reduction due to the project activity in the year. The thermal interactive factor is considered for projects with fossil fuel as source of energy. The case of energy saving in the temperate region is on the reverse as the implication of energy efficient retrofitting of the bulbs will not result in reduced energy consumption by the air conditioners as there will be more requirement of heating.

4.6 Maximum (Peak) Electricity Demand in UM



	2007	2008	2009	2010	2011	2012
M.D(kWh)	210,302	212,584	216,277	225,791	225,642	236,564
E.C(RM)	0	50,318.	88,632.	227,670	-3,713.	282,879

Note M.D = maximum electricity demand, E.C= extra cost due to increase in M.D.

Figure 4.5: Maximum electricity demand increase scenario and associated cost in UM

Maximum demand is the period determined by the power producers that consumption of electricity by any facility is highest (McQueen et al, 2004). That means the loading (electricity use) by the consumer like UM within this predetermined time is highest as compared to any other period of consumption. The billing rate for peak demand is always higher than normal billing. This is showcased in Tables 4.1-4.5 and 4.8. The billing rate for peak demand is a factor of more than 80 as compared to the normal billing per kWh of electricity consumed.

Maximum electricity demand as could be deduced from Tables 4.1-4.5 and 4.8 and represented in Figure 4.5 has increased over the years increasing more than 26MWh, a 12.5% leap in six years. Figure 4.5 highlights a decrease in maximum demand in 2011 possibly following same trend with the comparatively lower electricity consumption increase in 2011 as a result of implementation of temperature reduction of the air conditioners as mentioned earlier. Hence the higher the electricity consumption the higher the maximum demand and higher the bill. Therefore energy efficiency is important to have a positive impact on the peak demand.

4.7 Electricity consumption pattern in UM Residential Colleges

There are twelve residential colleges owned by the University of Malaya. This study has considered consumption in all except for 9th Residential College. This is because it is not within the main campus and its electricity requirement is supplied directly by TNB.

Table 4.6: Electricity consumption in University of Malaya residential college 2009-2011

Residential College	Electricity consumption in kWh		
	2009	2010	2011
1	619,646	631,432	561,304
2	679,386	805,020	713,912
3	966,445	959,099	698,009
4	547,970	564,588	536,986
5	389,968	537,834	672,579
6	916,096	874,264	876,066
7	651,007	694,415	613,435
8	897,900	829,971	817,968
10	617,365	641,211	592,317
11	907,712	892,351	791,874
12	2,613,043	2,480,633	2,324,468

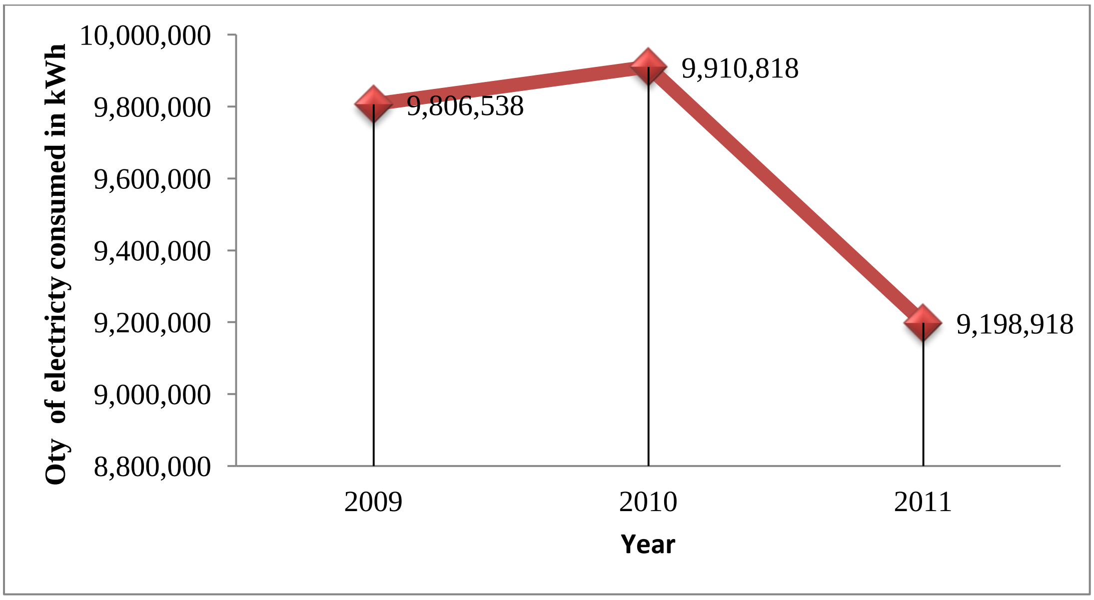


Figure 4.6: Electricity consumption trend in University of Malaya Residential Colleges

Electricity consumption in Residential Colleges is shown in Table 4.6 while the trend is as portrayed in Figure 4.6. Residential colleges are estimated to be responsible for 16% of total electricity consumption in higher institutions (Unachukwu, 2010). Comparing with Figure 4.2, it entails that the residential colleges has contributed 13.5%, 13.1% and 12.1% of the total electricity consumed in University of Malaya for the years 2009, 2010 and 2011 respectively. Generally it portrays a relatively stable consumption between 2009 and 2010 though there was 0.4% decrease in residential colleges' contribution to the total electricity consumption even with a little leap of year 2010 over 2009. A sharp reduction in consumption of 7.2% in 2011 against 2010 could have been as a result of increment in the hostel fees which has made some students park out, since they may have more leverage living off campus even though it might be same price. Also some hostels may have reduced intakes due to refurbishments.

Twelfth residential college has the largest floor area hence it remains the highest consumer of electricity among the residential colleges.

4.8 Energy Intensity in the Residential Colleges

Energy intensity could be used as a measure of the energy efficiency (Fenga et al. 2009). Saidur et al. (2009) has calculated energy intensity as:

EI= AEC/TFA – Equation 1

AEC – annual energy consumption in kWh

TFA – total floor area in m^2

This formula is used. Estimated results for 2010 and 2011 are as depicted in Table 4.7. 3rd Residential College appears to have the worst energy intensity. It is estimated that the energy intensities in residences is about 5-10% of office building consumption (Iwaro and Mwasha 2010) and that office buildings in Malaysia consumption is about 200-250 kWh/m^2/year (Aun, 2009, Jamaludin et al, 2011). Thus this study could conclude that 5th Residential College may be the only college residence in 2010 with energy intensity of conventional Malaysian consumption while the others show much higher energy intensity with between 100% and 700% more than the usual intensity rate. 2011 figure follows same trend in terms of being higher than estimated business as usual consumption for college residence though it shows general decrease in consumption.

Table 4.7 Annual electricity consumption, floor areas and energy efficiency in 11 residential colleges in UM.

	2010			2011		
R.C	AEC (kWh)	TFA (m^2)	E.I ($kWh/m^2/year$	AEC (kWh)	TFA (m^2)	E.I ($kWh/m^2/year$)
1	631,432	13,687.81	46.13	561,304	13,687.81	41.01
2	805,020	13,696.53	58,76	713,912	13,696.53	52.12
3	959,099	11,228.35	85.42	698,009	11,228.35	62.16
4	564,588	11,427.95	49.40	536,986	11,427.95	46.99
5	537,834	23,536.12	22.85	672,579	23,536.12	28.58
6	874,261	16,647.82	52.52	876,066	16,647.82	52.62
7	694,415	10,128.09	68.56	613,435	10,128.09	60.57
8	829,971	11,905.86	69.71	819,968	11,905.86	68.87
10	641,211	13,678.02	46.88	592,317	13,678.02	43.30
11	892,351	25,935.09	34.41	791,874	25,935.09	30.53
12	2,480,633	90,119.83	27.53	2,324,468	90,119.83	25.79

4.9 Waste Management in University Malaya

Biodegradable waste generated in University of Malaya is close to 5 tonnes per day. The recycling rate is less than 2% with about 3-4 tonnes composted monthly and the remaining being landfilled. The situation here could probably mean that University of Malaya is contributing to the externalities of the climate change shock. This may be surprising considering the status of the University as the top research university in Malaysia, and the fact that the waste could actually be turned into resources, with proper research and management.

The waste management practices in University of Malaya is diagrammatically illustrated in Figure 4.7

Figure 4.7: Waste Management practices in University of Malaya

Wastes 1-4 (mainly food waste, paper, aluminum cans) which come from faculties and cafeteria and residential colleges are gathered periodically about 2 times a day mainly by janitors. The wastes are sent to a temporary transfer station which is built in faculties and residential colleges. In these transfer stations bills are posted on the wall on the inside stating the respective sides for dropping of food waste and other wastes. JPPHB is responsible for hauling these waste from this temporary transfer station to the University Malaya central waste storage site (Figure 4.11) at the Damansara exit gate where the waste are transferred into roll-on roll-on (RORO) bins. JPPHB while moving the waste also have to get round to pick the yard waste. At this waste storage site, part of the food waste is composted.

4.10 Waste handling and emerging situation in UM

An average of 200kg/day of about 2,000kg recovered food waste is composted with 20-30kg of the garden waste. A diesel powered 12HP shredder with operating capacity to handle 40-50kg per hour is used to shred the garden waste and routinely mixed with food waste. The internal temperature of the compost heap isabout60-70˚C due to effective microbes; thereby one could see smoke when the compost is spread out to put in more food waste. Every two days there is aeration of the compost by turning the heap and after 14 days it is ready to be transferred into the curing container where it is allowed to stand for 14 days. The compost which has been tested and found free of pathogens using among other methods BS 5763: Part 8/ISO7251, BS5763: Part 7/ISO6888, BS5763: Part 7/ISO6579 for *E.Coli*, *staphylococcus aureus* and *Salmonella* respectively according to the University of Malaya Zero waste campaign is ready for packaging for sale and also for application in the organic farm (egg plant and chilli) developed by the Zero Waste Campaign which has existed after operation started almost 18 months ago.

Figure 4.8: ZWC organic farm.

The composting according to Zero Waste Campaign has not been economically sustainable as only about 14% yield of the total input is obtained as compost and also with sale of 10kg of chilli at RM5/kg and RM2.5/kg for egg plant of 30kg weekly quantity, it could hardly pay for the two workers who are on a daily pay of RM90. The organic farm is shown in Figure 4.8.

Business as usual has made it very difficult to understand the real value of aversion of environmental externality due to the composting. However ecological efficiency of this activity cannot be overemphasized but more needs to be done in terms of social and infrastructural requirement to reduce the amount of waste generation. Basic structures especially bigger place than the 150m^2 Zero Waste Campaign location and necessary machineries are also needed for smooth operation. Figure 4.9 shows space for composting.

Figure 4.9: ZWC composting site at UM central waste storage site at Damansara exit

November 2012 ushered in a new approach and an addition to the quest for Zero waste campaign to advance reduction of waste sent to the landfill. A digester depicted as Figure 4.10 which cost RM100, 000 has been purchased for Research and Development.

The digester is able to digest about 100kg of food waste mainly rice but for now only about 40kg is processed. It has a gas retention tank of 2.4m^3; with operational efficiency 1.5m^3 of gas with an input of 10kg waste. At status quo with non availability of gas capturing equipment, the resultant gas is flared. Though this is a research and development project, flaring the gas is a contribution to GHG emission. Therefore gas capture should be incorporated.

Figure: 4.10 Digester at ZWC site.

Landfilling is a major issue in Malaysia as over 90 percent of municipal waste is landfilled with about 50% of the quantity being food waste (NC2, 2011). With much less than a tonne of the waste generated composted and digested, much more than 4 tonnes are sent to the landfill daily. DBKL appointed contractor and also JPPHB appointed contractor haul over 4 tonnes of waste daily from the University Malaya central waste storage site at the Damansara exit gate to the Taman Beringin transfer station which is about 20km away, then the waste is finally buried at the Bukit Tagar sanitary landfill. Figure 4.12 shows a truck loading for landfilling. The externality associated with this could be very high considering the climate change related possibilities in emission both from transportation and in the waste emissions of GHG. University of Malaya could be responsible for over 1,750 tCO_2e from landfilled waste per annum. The cost associated with landfilling of the waste borne by UM is about RM 1600 per day inclusive of RM 64/tonne tipping charge.

Figure 4.11: UM central waste storage site

Figure 4.12: Truck loading waste for landfilling

4.11 Conclusion of objective 1: To determine electricity consumption and ascertain waste management practices in University of Malaya

In wrapping up for this objective, the electricity consumption in University of Malaya has been quantified, the residential colleges form 12-14% of the total electricity consumption which is within what some researchers has estimated as residential colleges portion of electricity consumption in schools, Yet the energy intensity in the residential colleges may be considered as high in Malaysia with consideration on comparative assessments of office and residential consumption potential. This makes a point for a more sustainable consumption.

Onsite assessments results show that the lowest temperature of air conditioners is 24˚C and over 90% of lighting technology is T8. With lighting and HVAC estimated to take up more than 80% of the total electricity need in an educational institution, there is need to critically look into more efficient technologies especially for the lighting and possibly increase the thermostat set temperature by 1-2˚C inclusive of vigorous enlightenment of the university community such as awareness program, pamphlets distribution etc on the need and ways for reduction of electricity consumption.

The waste management practices could be said to be still crude since almost all waste goes to landfill. The Zero Waste Campaign is on the right track, yet much more needs to be done like management support for capacity building.

University of Malaya's electricity consumption and waste management practices needs to be improved, this could drastically reduce the ecological footprint of the institution and enhance its socio-economic status.

4.12 Estimation of the greenhouse gases emission from University of Malaya related to energy consumption and waste management in correlation with CDM.

4.13 University of Malaya's estimated carbon footprint from electricity consumption.

The direct and indirect greenhouse gas associated with the electricity consumption in University of Malaya has been estimated using equation 2 (Shekarchian, 2011). Figure 4.13 shows the trend of embodied CO_2e emission as a result of University of Malaya's electricity consumption; however, this is exclusive of SO_2 emission which increased from about450 tonne in 2007 to 605.45 tonne in 2011. The five year emission is equal to depletion of about 400,000 tonnes of coal or about 105,530,600 gallons of gasoline and would probably take preserved forest over 100 times size of UM 10 years for sequestration of this amount. Without any mitigation measure in place and with a conservative assumption of 20% increase in emission by 2020 as against 2011 level and a population increase of 7.5 % , University of Malaya's per capita emission just on electricity consumption would be at par with Yale University total per capita emission of 8.7tonne/year. This is also on assumption of 7.5% population increase of Yale against the present 15,619 but they are meeting up their target to cut down the emission.

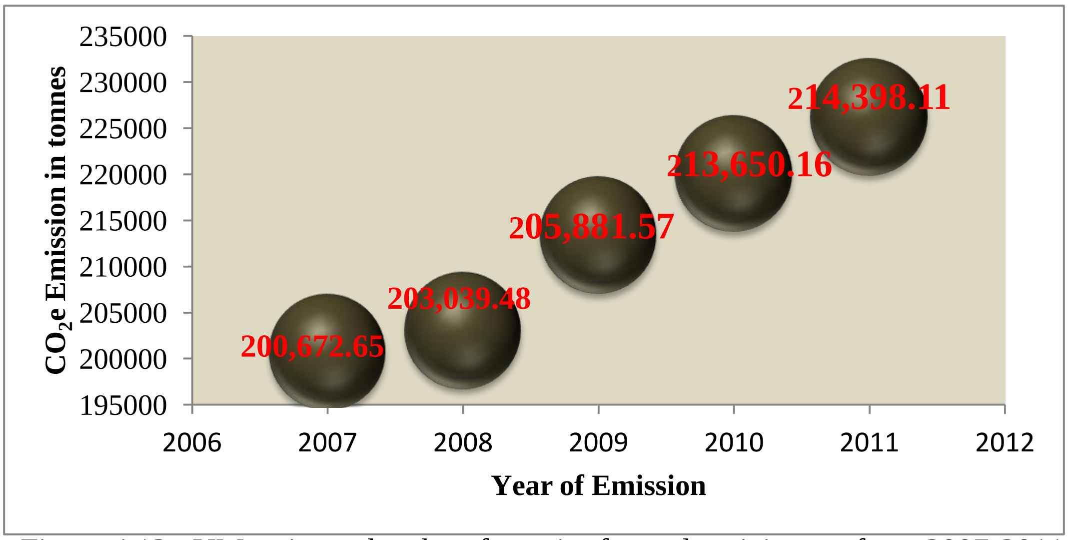


Figure 4.13: UM estimated carbon footprint from electricity use from 2007-2011

$PE_{FC,j,y} = Q_E \times \sum CP_j / \eta_O \times FC_{i,j,y} \times EF_i$ – Equation 2

Where $PE_{FC.j,y}$= Total Emissions by UM due to usage of electricity generated and transmitted from fossil fuel powered grid j during year y in tCO_2e

Q_E = Amount of electricity consumption in UM + 10% transmission loss in MWh

CP_j = contribution of various power plants to electricity generation in %

η_O = Thermal efficiency of power plants.

$FC_{i,\,j,\,y}$ = Fuel type i contribution to electricity generation in power plant j during year y (%)

EF_i= Emission factor of fuel type i (tonnes/MWh)

i = The fuel types utilized in power plant j during the year y.

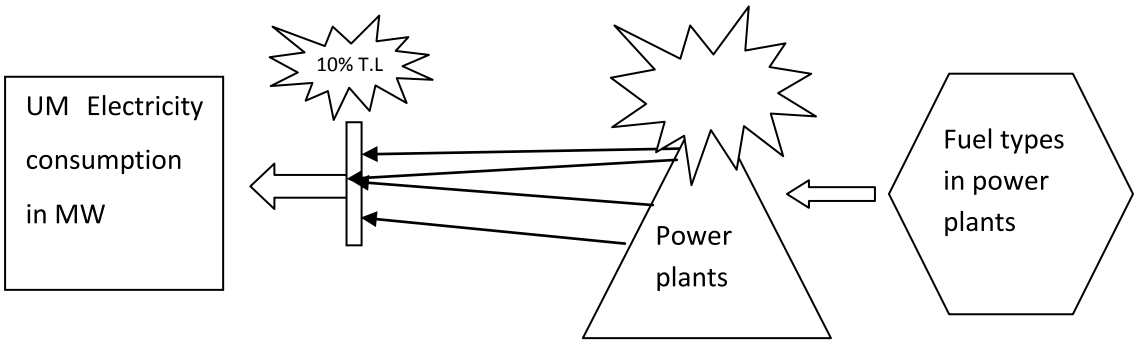


Figure 4.14 : Pathway of electricity supply to University Malaya

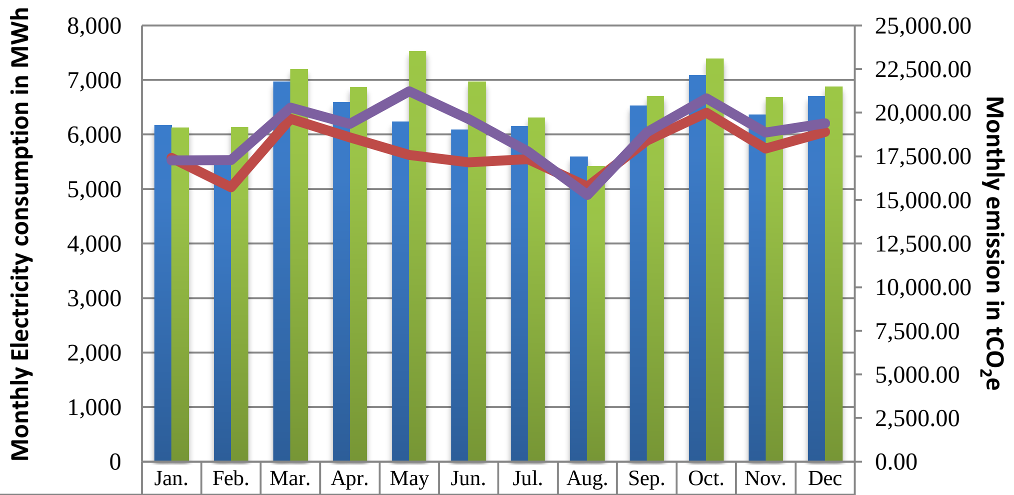
Electricity demand in University of Malaya has followed same trend with the countries consumption. Furthermore the primary energy sources are natural gas, petroleum, coal, hydroelectric plants and petroleum products like diesel.

The percentage contribution of the various power plants has been worked out using Table 3.2. For the percentage contribution for 2009-2012; this research considered using the contribution of various fuel mix for the years. This is because the data on the composition of fuel consumption in power plants are not available for the period. In addition the biomass and hydroelectric plants are considered zero emitters due to efficiency of modern hydropower plants reach 90% (Dursan and Gokcol, 2011). Figure 4.14 depicts UM energy pathway.

Huge amount of pollutants including nitrogen oxide (NO_X), carbon monoxide (CO), sulphur dioxide (SO_2) and carbon dioxide (CO_2) are emitted by thermal power plants utilizing fossil fuel as their fuel sources.

Table 4.8 Electricity use in UM main campus (2012)

Month	**Consumption (KWh)**	**Rate (RM)**	**Max Demand (KWh)**	**Rate (RM)**	**New Energy fund tax**	**Total bill after 10% discount (RM)**
Jan-12	6,121,706.00	0.312	18,900.00	25.900	21,595.34	2,181,129.39
Feb-12	6,127,836.00	0.312	19,374.00	25.900	21,723.04	2,194,027.33
Mar-12	7,196,681.00	0.312	20,347.00	25.900	24,951.17	2,520,067.76
Apr-12	6,865,963.00	0.312	20,612.00	25.900	24,084.28	2,432,512.41
May-12	7,527,095.00	0.312	21,339.00	25.900	26,110.20	2,637,130.57
Jun-12	6,962,268.00	0.312	19,390.00	25.900	24,069.86	2,431,055.61
Jul-12	6,303,064.00	0.312	17,599.00	25.900	21,801.33	2,201,934.39
Aug-12	5,419,934.00	0.312	16,873.00	25.900	19,152.27	1,934,379.37
Sep-12	6,969,188.00	0.312	20,785.00	25.900	23,647.88	2,388,435.82
Oct-12	7,385,222.00	0.312	20,945.00	25.900	25,619.98	2,587,618.27
Nov-12	6,685,740.00	0.312	20,691.00	25.900	23,596.63	2,383,259.63
Dec-12	6,873,515.00	0.312	19,709.00	25.900	23,895.00	2,413,394.80



	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec
2011 M.E.C	6,171	5,573	6,965	6,590	6,232	6,086	6,146	5,586	6,527	7,089	6,365	6,699
2012. M.E.C	6,122	6,128	7,197	6,866	7,527	6,962.	6,303	5,420	6,696	7,385	6,686	6,874
2011. M.CE.E	17,402	15,716	19,641	18,583	17,574	17,162	17,331	15,752	18,406	19,991	17,949	18,891
2012. M.CE.E	17,264	17,281	20,295	19,362	21,226	19,633	17,774	15,284	18,882	20,825	18,854	19,384

Note M.E.C and M.CE.E = monthly electricity consumption and monthly carbon equivalent emission respectively.

Figure 4.15: UM's 2011/2012 monthly electricity consumption and estimated associated emission.

Table 4.5 and 4.8 are integrated and Figure 4.15 displays the trend of electricity consumption and associated carbon equivalent emission for the years 2011 and 2012. There was a significant leap in electricity consumption and associated emission in 2012. A total of about 226,066 tonnes of carbon equivalent emission could have been emitted in 2012, an increase of about 5.5% over 2011 figure and also about 226 tonnes higher than the cumulative increase between 2008 and 2011. This leap may be associated with the commissioning of new buildings as mentioned earlier.

4.14 Emission pattern in Residential Colleges

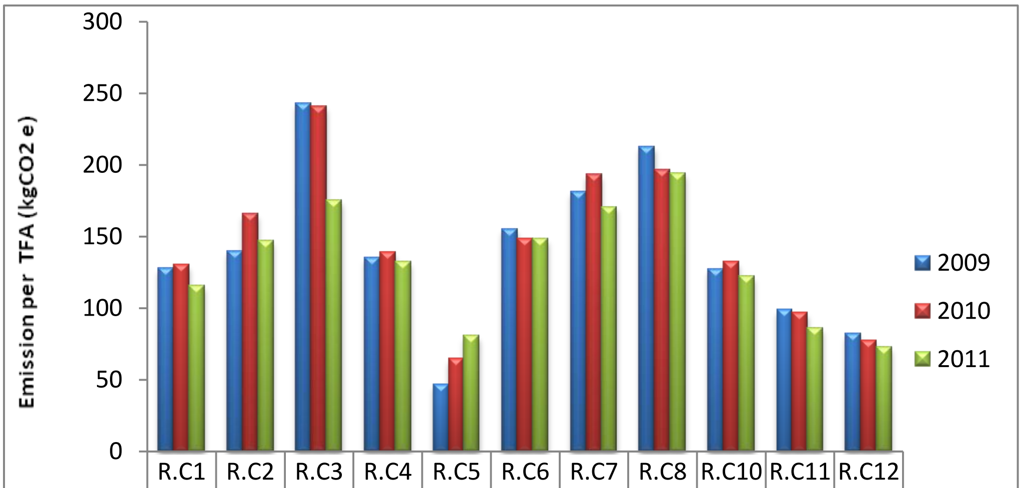
Equation 2 has been applied in the calculation of the carbon emission equivalent (Em) depicted in Table 4.9. The total estimated emission due to electricity consumption has been found to be 27,655.2, 27,948.6 and 25,945.9 tCO_2e for the years 2009, 2010 and

2011 respectively, hence contributing 13.5%, 13.1% and 12.1% of the estimated University of Malaya's emission from electricity consumption for 2009, 2010 and 2011 respectively. This follows similar trend with the electricity consumption contribution to the institution's total.

Table 4.9 Residential Colleges associated emissions from electricity use

	2009		2010		2011	
R. C	AEC (kWh)	Em(tCO_2e)	AEC (kWh)	Em(tCO_2e)	AEC (MWh)	Em(tCO_2e)
1	619,646	1,747.6	631,432	1,780.6	561,304	1,582.9
2	679,386	1,915.9	805,020	2,270.2	713,912	2,013.2
3	966,445	2,725.5	959,099	2,704.7	698,009	1,968.4
4	547,970	1,545.4	564,588	1,592.1	536,986	1,513.3
5	389,968	1,099.8	537,834	1,516.6	672,579	1,896.7
6	916,096	2,583.4	874,264	2,465.5	876,066	2,470.6
7	651,007	1,835.8	694,415	1,958.2	613,435	1,729.8
8	897,900	2,532.1	829,971	2,340.6	819,968	2,312.4
10	617,365	1,741.1	641,211	1,808.2	592,317	1,670.3
11	907,712	2,559.7	892,351	2,516.6	791,874	2,233.2
12	2,613,043	7,368.9	2,480,633	6,995.3	2,324,468	6,555.1

12th Residential College remains the highest contributor among the residential colleges, with at least 25% of the total within the three years under review, yet it remained the least per floor area emitter apart from 5th Residential College that has an average estimated emission of 63.9kg. 3rd Residential College as seen in Figure 4.16 seems to be the most inefficient with an average of 220kg/TFA. It could be ascertained that there has been a general reduction in the emission over the three years, which could possibly be attributed to reduction of number of students in hostels due to increase in hostel fees or and reduced intake due to refurbishments. Also stringent enforcement on the use of some electrical appliances like electric cooking stove, ironing could have helped in the general reduction.



	R.C1	R.C2	R.C3	R.C4	R.C5	R.C6	R.C7	R.C8	R.C10	R.C11	R.C12
2009	127.7	139.9	242.7	135.2	46.7	155.2	181.3	212.7	127.3	98.7	81.8
2010	130.1	165.8	240.9	139.3	64.4	148.1	193.3	196.6	132.2	97	77.6
2011	115.6	147	175.3	132.4	80.6	148.4	170.8	194.2	122.1	86.1	72.7

Figure 4.16: The emission in the residential college (R.C) per floor area

4.15 Comparison of emission in selected UK universities and University Malaya

In the United Kingdom where sustainability status of the higher institutions are yearly measured through the ‘People and Planets Green League. Evaluation is done by People and Planet initially called Third World First on inception in 1969. It is the largest and most recognised student network in Britain campaigning to end world poverty, defend human right and protect the environment (People & Planet, 2013). The result for 2011 shows that more than half of the institutions there have a greenhouse reduction plan against 2005 figure. Table 4.10 indicates that University of Malaya's estimated CO_2e emission on electricity to be very high and there is no emission reduction plans yet. Except for University of Aberdeen and King’s College that have increased emission in 2011, the others have greatly improved with University College London having the greatest milestone in reduction of greenhouse gases. University of Malaya's per capita carbon emission from the estimated amount in 2011 from energy is 104% higher than Cranfield's University figure which was the biggest per capita emitter among institutions in the United Kingdom. Also a combination of the per capita emission of Cranfield University, University of Oxford and Robert Gordon University were found to be less than the UM's figure.

Table 4.10 : Selected institution CO_2e per capita emission in 2011

Institution	Per capita CO_2e emission/year (kg)	Milestone in emission reduction vs 2005 figure (%)
University Malaya	7393(electricity only)	NA
Cranfield University	3627.5	9.5
University College London,	2391.5	51.5
University of Oxford	2778.3	23.4
University of Aberdeen	1568.2	-2.3
Robert Gordon University	974.1	24.2
University of Cambridge	2944.8	10.7
University of Sussex	1734.2	8.3
King's College	2,089.4	-10.4

4.16 Waste Management and associated carbon footprint in University of Malaya

The waste management scenario and the probable externalities outcome of the present management status have been highlighted in Figure 4.12.Waste that is sustainably managed is very minimal with direct carbon emission equivalent due to landfilling probably amounting to over 1,750 tonnes per annum. Weekends and holidays have been excluded from this calculation. Leachate is also a major issue here where almost 135,000 litres could be discharged yearly. Ludwig et al. (2003) has documented that apart from uncontrolled gas release from landfill to the atmosphere, pedo and hydrosphere could be affected by the emissions which are mainly in liquid form and result due to percolating rainwater.

Part of the indicators used in the people's and planet league table for evaluation of the green status of 142 universities is sustainable waste management. The average recycling rate among these numbers of Universities is over 45%. University of Malaya per capita waste mass is the lowest as compared to the other universities. Note that only organic waste is considered for UM. Table 4.11 could also enhance the fact that all the institutions with bigger per capita waste mass except for Cranfield University generate power onsite using Combined Heat and Power (CHP). Probably major part of their waste is utilized in the onsite power generation. In CHP systems, the fuel sources could include waste heat, biomass, coal, natural gas or oil (USEPA, 2013).

Table 4.11 : Selected institution waste mass per capita in 2011

Institution	Per capita waste mass (kg/year)	Recycling rate (%)	Onsite Power generation (kWh)
University Malaya	52.14(organic)	<2	-
Cranfield University	211.36	31.66	-
University College London	113.32	55.18	30,854,190
University of Oxford	60.27	22.87	-
University of Aberdeen	94.21	36.57	7,622,596
Robert Gordon University	72.42	36.03	-
University of Cambridge	307.5	29.26	1,530,000
Imperial College	360.26	60	67,125,220
University of Sussex	4,317.01	97.88	11,270,058
University of Birmingham	182.8	44.34	72,550,270

University of Sussex is the highest per capita waste generator, bigger than the combined total of the compared by 200%, however its high recycling rate, about the highest among higher institutions in United Kingdom and onsite power generation makes it a comparatively low carbon emitter as Table 4.10 explains. It could been seen that Cranfield which is among the biggest waste mass per capita producers is the biggest carbon emitter possibly because it could have been landfilling about 135kg of waste per head of the population instead of utilization for power production. This study emphasizes the fact that assumptions by other institutions in arriving at their figures have not been considered.

Figure 4.17 also hints on the potential of a more sustainable handling of the waste through energy generation from the waste. This would be discussed further in waste section.

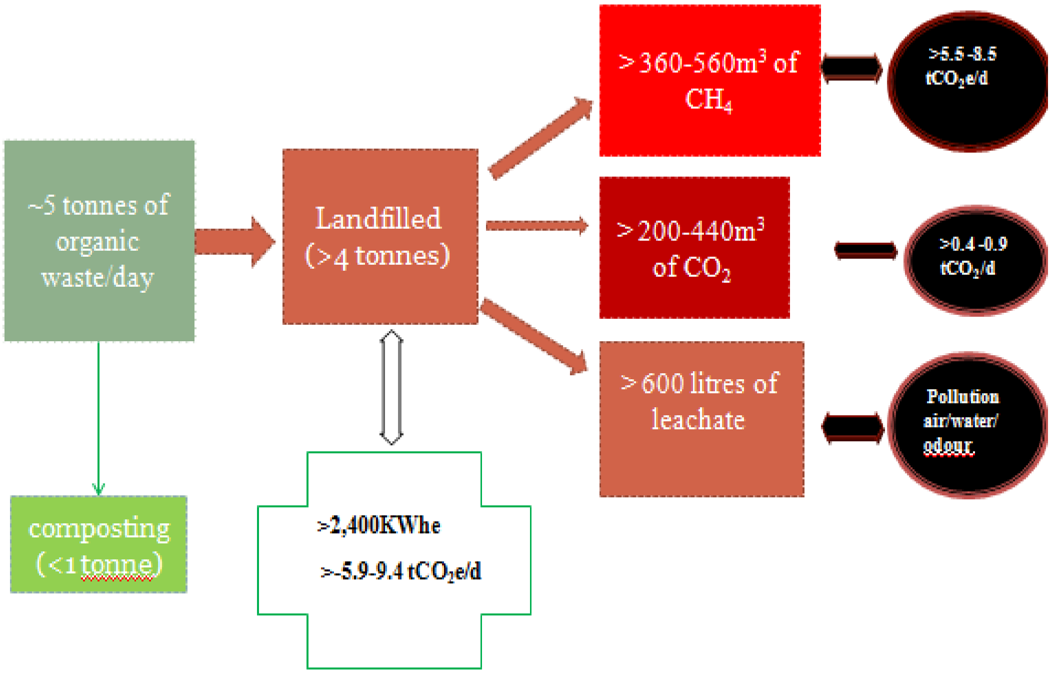


Figure 4.17: Waste Management / Externalities & Potentials associated with UM's Organic waste

4.17 Conclusion of objective 2: To estimate the greenhouse gases emission from University of Malaya related to energy consumption and waste management in correlation with CDM.

Concluding for this objective 2, University of Malaya's carbon footprint from electricity use has and is still on the rise. Estimation gives an idea that the largest increase of emission year on year was in 2012 over 2011. The institution could be conceptually seen as a high emitter apparently due to its source of electricity, heavily dependent on fossil. TNB supplies its electricity need with over 90% of the primary source of the electricity fossil fuel based.

A comparative assessment with other lead universities shows the high emission trend, however the methodology of the other lead universities detailed assessment of their carbon equivalent emission has not been considered.

The residential colleges' contribution to the total electricity consumption was responsible for between 12-14% of the total estimated carbon emission equivalent of UM. 12^{th} Residential College remains the highest emitter due to its large floor area but lowest behind 5^{th} Residential College in terms of emission per floor area. 3^{rd} Residential College has the worst efficiency among the rest.

Estimated emission from the waste sector of the university shows that the institution is a low per capita emitter comparatively with some other lead universities like in the United Kingdom; however we have to also reiterate that the methodology of the other universities assessments of their emission from the waste is not considered.

Yet University of Malaya could reduce its GHG emissions from existing electricity use and waste management practices.

4.18 Eligibility of University of Malaya for CDM

University of Malaya as the pioneer and number one ranked university in Malaysia will be fully granted autonomous status in the year 2015. It strategizes to improve its world university ranking to below 100th position by 2015; hence all avenues necessary for exploration to increase its global foot print especially in the sustainability aspect is essential. Being part of CDM to a great extent shows not only the consciousness to the precarious situation of climate change on which the globe hangs on now but also an organisation's resolute to contribute to the climate change mitigation.

Clean Development Mechanism (CDM) as explained earlier must involve developed and developing nations. Malaysia is a developing nation with UM as its oldest university. Key feasible projects for CDM in Malaysia with 19 specific potential project activities are enumerated in Table 2.1. Based on this work, our consideration is on energy efficiency group specifically on Demand Side Management (DSM) and for the waste management group; focus is on power and heat production from anaerobic digestion of biodegradable waste. These projects are feasible in removal of greenhouse gases from the atmosphere. Due to characteristic fuel sources for generation of power assessed by University of Malaya which are fossil and also the present waste management practices where a big chunk of the organic waste is landfilled, room exist for the institution to take a lead among universities in Malaysia in contribution to mitigation of climate change. This is achievable through Energy efficiency and waste management project activities under CDM.

Energy efficiency through Demand Side Management provides environmentally sustainable mechanisms for reduction of greenhouse gases emission as well as reduction in energy consumption which will also cut the necessity for increased natural resources depletion. This is supported by Allcott & Greenstone (2012) with energy efficiency as a win-win opportunity. Limiting the amount of waste to the landfill through power and heat generation also could limit primary energy resource depletion constraint.

4.19 Energy efficiency improvements projects

University of Malaya in the present campus has existed for over 60 years; hence many structures in this institution are comparatively aged with less efficient facilities. Only about 20% of the current existing built floor area in the main campus is new. These structures are ones built within the last 10 years, so we assume that they are more efficient than the older ones, so less consideration. It is estimated that about 90% of the lighting technology in University of Malaya are T8 (Mahlia, 2011), therefore opportunity could be in the coffers for improvement in the pre-last decade buildings. This could offer a cushion to the load on the grid and by implication help in climate change mitigation.

Under sectoral scope:03, EB 66, Methodology AMS 11.N/Version 01.0, DSM energy efficiency activities for installation of energy efficient lighting and/or controls in buildings are elaborated showing baseline and monitoring methodologies for some selected CDM project activities. This methodology could be applied to non-residential like offices, educational institutions etc. 60GWh is the upper limit of the energy saving from retrofitting with energy efficient electrical technologies.

Specific selected project activities eligible are; retrofitting of existing electric lighting fixtures, lamps with more efficient technology, permanent de-lamping of electric lighting fixtures with or without use of reflectors and installation of lighting controls, such as occupancy sensors or timers (with or without delamping or changes to fixtures, lamps, or ballasts) in order to reduce electric lighting lamp operating hours.

Lighting technologies; T12 fluorescent light bulbs, magnetic –ballast, incandescent A-19 light bulbs and compact fluorescent lights lower than 6,000 hours lamp life are not eligible for CDM under the DSM methodology. Consequently Table 4.12 presents the prerequisite for participating in the eligible projects under DSM as outlined, it also highlights UM's position as compared to the prerequisites.

Table: 4.12: Evaluation of the prerequisite for qualification as Demand-side energy efficiency activities for installation of energy efficient lighting and/or controls in building and the University of Malaya current features.

Features	Prerequisite for DSM CDM project activity	Project considered (UM)
Area	Non-residential	Educational institution
Lighting technology	CFL with > 6,000 hours lamp life	T5 lamp life = 18,000
Energy saving	Total energy saving < 60 GWh	UM total saving <60 GWh

Adapted from UNFCCC (2012)

In this section University of Malaya's eligibility through various indicators which are indicated in standard Project Design Documents (PDD) as laid down by UNFCCC. Information required for a project to get international approval as a CDM project are contained in the Project Design Document (Malaysia Energy Centre, 2009) They include a description of the project activity, the projects contribution to sustainable development based on socio-economic, technological and environmental well-being. They have to be analogous with the key aims of CDM.

Two key aims of CDM are; to help non Annex 1 countries that host CDM projects to enhance their sustainable development status and in addition provide environmentally sound technologies, economic viability and eliminate issues that could pervert the realisation of the project. Moreover Annex 1 countries flexibility for realization of their committal target is enhanced through the transfer of carbon credit. This is as a result of sustainably implemented projects in developing countries.

4.20 Socio-economic sustainability

In carrying out DSM project activity on energy efficiency, necessity arises for skilled and semi- skilled manpower. To retrofit with energy efficient T5 fluorescent, there will be need for a bit of rewiring. The ballast of the existing T8 fluorescent will have to be removed to comply with UNFCCC standard that to be eligible for this methodology, fixtures must be modified so pre- existing bulbs will not be reinstalled later. Therefore there is need for training which shall cover the design intent of the system, review of control drawings and schematics and health and safety issues including briefs on the interactive effects of the retrofitting with the environment. With all these and more, the knowledge and skills base of the employees involved in this project activity would have been enhanced. Furthermore the energy efficiency project activity would also evolve business opportunities in technology supplies like supplies for the T5 fluorescent tubes and other accessories that will be required for the smooth execution of the project activity. This opportunity is not limited or tied to the project in University of Malaya but will also affect other energy efficient project that might come up in Peninsular especially as a result of other institution following up due to the success status of University of Malaya.

Energy efficiency measure has been proven as one of the best approaches cost wise in optimizing commercial profitability. It will improve the energy bills, help in conservation of internal primary energy as well as the reduction in primary energy sources like coal and crude oil in particular. With other establishment following with

University of Malaya's strategy, the robustness of Malaysia's energy security will boost the country's buoyancy against disruptions and epilepsy of imported energy prices.

4.21 Technological sustainability

University of Malaya will be energy efficient due to the retrofitting with T5 fluorescent tubes which will replace the energy consuming T8 tubes. Replacing standard T8 36 W and T8 18W fluorescent technology with T5 28W and T5 14 W respectively will give almost same luminous flux (Mahlia, 2011) and with far decreased energy requirement. There are high possibilities of replication of this project activity in other upcoming projects based on the accomplished success of University of Malaya's. Many documentation on the fact that 50% energy saving is gained with the preference of T5 over T8 (Mahlia, 2011) as the benefits of this retrofitting option has shown to be worth applying and has currently lead to a modal shift from the conventional T8. National University of Singapore in its drive to reduce their energy consumption and associated carbon emission has installed T5 in the residential hostels (NUS, 2012).

4.22 Environmental sustainability

Implementation of this project activity of energy efficient measure will lead to a reduction in the net energy utilization in the facility in relation to a conventional facility without similar project activity implemented in it. The power requirement from the grid will be reduced by this project activity thereby reducing the electrical load on the grid invariably leading to a reduction of grid connected power plant electricity generation. The multiplier effect of this is salient. Reduced thermal power generation apart from its sustainability realm of increasing the life span of non-renewable resources, there is reduction of greenhouse gases emission which is the major cause of climate change.

4.23 Conclusion for objective 3: To evaluate the eligibility of University Malaya for Clean Development Mechanism

The first criterion for CDM is that it has to be between an Annex 1(developed) country and a non Annex 1 (developing) country of which University of Malaya sits well into. The objectives of CDM according to Article 12 of the Kyoto Protocol is to help non Annex 1 countries like Malaysia to achieve sustainable development, hence contributing to climate change mitigation and also assist Annex 1 countries to meet their emission caps.

A number of projects have been enlisted as potentials in the CDM. University of Malaya is in a developing country and based on assessments of the existing status in the institution, University of Malaya could participate in CDM by engaging in energy efficiency DSM as shown in Table 2.1, also based on waste; it could be engaged from the perspective of power and heat production from waste by using biogas generated from the anaerobic digestion of biodegradable waste to generate electricity.

These projects will enhance University of Malaya's sustainable campus status environmentally, technologically and socio-economically. It will also help any of the Annex 1 countries that sign the Emission Reduction Purchase Agreement (ERPA) to meet its emission cap with the ultimate aim of preventing increase in the greenhouse accumulation in the air which could aggravate climate change.

4.24 Estimation of the potential environmental and economic benefits of greenhouse gases reduction from energy and waste management in University Malaya through Certified Emission Reduction (CER)

This objective is analyzed based on a case study of one of the major facilities in University of Malaya, the main library and from the result there should be a possibility of extrapolation in facilities with similar existing technologies.

4.25 Case study of University of Malaya main library for CDM

4.25.1 Introduction

Figure 4.18: Front view of University of Malaya main library

The UM main library showcased in Figure 4.18, a four floor building with total floor area of 194,734.05 ft^2 (18,091m^2) was built in two phases with commissioning year 1959 and 1997 for phase one and two respectively. It has continued to undergo periodic minor renovations in order to meet increased necessities.

The full seating capacity is about 1610; however the average number of library users per day is 2,319. On week days the official period for library users is between 8am to 10.30pm with extended closure at 12pm during the examination period. These are exclusive of weekends with less operating hours between 8am and 4.30pm.

4.25.2 Existing facilities

The four floors of the main library all have book shelves and carrels facilities. The seating for readers are from level 2 to 4. There are 53 carrels (private study room) spread over all floors with 21 for the visually impaired. The floor area of the carrels range between $3m^2$ and $4m^2$ with airconditioner vent dimension of about $2ft^2$. Over 95% of lighting technology used in the library is T8 fluorescent with dimension 2 feet and 4 feet of wattage 18watts and 36watts respectively (Figure 4.19).

Figure 4.19: T8 lighting system in UM with ballast and starter

The air conditioning system is central unit and operates 24 hours a day which may be probably because of the books. Hence the main library is noted as one of the main source of energy consumption in University Malaya and could be playing a lead role factor in the grid electrical load as well as the maximum electricity demand. Thereby the main library becomes a major potential in the quest for University of Malaya to reduce its energy consumption and the gain here could be replicated in other similar facilities.

4.25.3 Proposal for CDM

By the year 2015, University of Malaya would have gone into an autonomous status, where it would be expected to source its own funds for research and development and take care of other operational issues. Hence any approach that could improve the economic base of the institution should be explored especially when it has to do with approach through a sustainable path that could help to reduce the ecological footprint of the institution. A sustainable approach could help in establishing deeper the global footprint of University Malaya especially with its quest to be in the first 100 globally ranked universities in about quarter of a decade.

Clean Development Mechanism offers a green platform for economic, social and environmental improvement. Hence retrofitting of the existing luminaries with more energy efficient T5 fluorescent could be a leap in the quest to reduce carbon emission, contributing to mitigation of climate change.

4.25.4 T5 Fluorescent

Figure 4.20: T5 fluorescent tube

In the resolve by mankind to find a solution to the high concentration of greenhouse gases in the atmosphere, T5 results as a lighting technology with high impact in energy savings. It has been documented that T5 could save about 50% of energy needed to operate a T8 bulb while still at same time giving light output equivalent to conventional fluorescent lights (Mahlia, 2011).

The diameter of the T5 shown in Figure 20is 16mm (Philips, 2012).Life span of this relatively new technology is about 18,000 hours at 5% life output reduction while the T8 is about 20,000 hours but with 20% reduction in output over its life span (Mahlia, 2011). It is smaller than the T8 and cannot be directly fixed into the T8 fixture, so adapter becomes essential. UNFCCC AMS-11.N-Demand side energy activities for the installation of energy efficient lighting and/or controls in building version 1 shows a potential in retrofitting from T8-T5 technology. UNFCCC has stated that one of the main criteria for eligibility for this methodology is that fixtures must be modified in order to avoid reinstallation of pre-existing lamp. The T5 due to its smaller size as compared to the existing T8 inclusive of its inbuilt ballast makes conversion kits necessary. Therefore with the conversion kits, a bit of rewiring will be needed and re-installing the pre-existing lamp is ruled out. Therefore the proposal fit into CDM for evaluation.

4.25.5 Existing energy consumption in library

Calculating the electricity consumption by the pre-existing lighting technology is an essential pre-requisite to CDM assessment. To do this, this research has incorporated the method from Di Stefano (2000) and Mahlia (2011), who have calculated the yearly energy consumed by existing lighting technology using the following equation:

$EC = \frac{N \times W \times OH}{1000}$ - Equation 3

Where EC -Total energy consumption

N- Number of lamps

W-Power consumption per lighting system

OH- Operating hour of the lighting system.

Results are illustrated in Table 4.13

Table 4.13: Existing lighting energy consumption in UM's main library

Lighting technology	Quantity	Total energy consumption (MW)
2 feet T8 18W florescent	479	129.33
4 feet T8 36W florescent	6,109	3,298.86

Table 4.13 potentially validate that the existing T8 lighting in the library consumes almost 3,500MW of electricity per year. This is about 5% of the total annual average of electricity consumption in University of Malaya. Its inefficiency is highlighted considering the library's share of the total University's floor area and high electricity intensity of 190kW/m^2/year just from lighting. This is almost the average total energy intensity of the average office in Malaysia, pinpointing the necessity for energy saving consideration.

4.25.6 CDM lighting energy savings evaluation

Retrofitting is aimed at among other ecological consideration to save energy and cost. The savings due to retrofitting is the difference between the energy consumption in the existing condition and after retrofitting.

Table 4.14 presents the energy savings due to retrofitting. It has been estimated using equation 1 of AMS 11.N/ version 01.0 sectoral scope: 03EB 66 CDM approved methodology for Demand-side energy efficiency activities for installation of energy efficient lighting and/or controls in building herein Equation 4:

$ES_y = \sum(1/1{,}000{,}000) * [(W/fixture_{b,u,i} * N_{b,u,i} * Hours_{b,u,i}) - (W/fixture_{p,u,i} *$

$N_{p,u,i,y} * Hours_{p,u,i,y})]$ - Equation 4

Where ES_y -Lighting energy savings associated with project in year y (MWh)

$W/fixture_{b,u,i}$-Baseline lighting demand per fixture of type i in usage group u (Watts)

$W/fixture_{p,u,i}$ -Project lighting demand per fixture of type i in usage group u (Watts)

$N_{b,u,i}$ - Quantity of baseline affected fixtures of type i in usage group u

$Hours_{b,u,i}$ - Baseline operating hours for operative lighting fixtures of type i in usage group u in a year (hrs)

$Hours_{p,u,i,y}$ - Project annual operating hours for operative lighting fixtures of type i in usage group u in a year (hrs)

u- Building usage groups with similar operating hours

Table 4.14: Energy savings from retrofitting existing lighting in UM library

Lighting technology	Quantity	Energy savings (MW/year)
2 feet T5 14W florescent	479	169.5
4 feet T5 28W florescent	6,109	6.7

Emission reduction due to the retrofitting has been estimated to be 484.12 $tC0_2$per year. The estimation was done integrating UNFCCC equation 3 and 4 of AMS 11.N/ version 01.0 sectoral scope: 03EB 66 CDM approved methodology for demand-side energy efficiency activities for installation of energy efficient lighting and/or controls in building herein equation 5 and 6:

$ER_y = [ES_y * (1 + IF_{e,c} + IF_{e,h}) * \frac{3{,}600{,}000kJ}{1MWh} * EF_{CO2,ELEC,y} / (1 - l_y)] + TIF_y$ - Equation 5

$TIF_y = [(ES_y * IF_{ff,c} * EF_{CO2,ff,c}) + (ES_y * IF_{ff,h} * EF_{CO2,ff,h})] * \frac{3{,}600{,}000kJ}{1MWh} y$ - Equation 6

Where ER_y - Emission reduction in year y,($tC0_2$)

$EF_{CO2,ELEC,y}$ - Grid electricity emission factor in year y

$IF_{e,c}$ - Interactive factor for electric space cooling system impacts in building in which project is implemented; factor is zero if building has no electric space cooling.

$IF_{e,h}$ - Interactive factor for electricity space heating system impacts in building in which project is implemented; factor is 0 if building has no electric space heating.

$IF_{ff,c}$ - Interactive factor for fossil fuel based space cooling system impact in building in which project is implemented; factor is zero if building has no fossil fuel based space cooling

$IF_{ff,h}$ - Interactive factor for fossil fuel based space heating impacts in building in which project is implemented; factor is 0 if building has no fossil fuel based heating.

l_y - Average annual technical grid losses (transmission and distribution) during year y for the grid serving the locations where devices are installed.

TIF_y - Thermal interactive effect

$EF_{CO2,ff,c}$ - Emission factor for fossil fuel(s) used in cooling system(s) ($tC0_2$/kJ)

$EF_{CO2,ff,h}$ - Emission factor for fossil fuel(s) used in heating system(s)($tC0_2$/kJ)

The crediting period for this project activity is ten years; the estimated total amount of CO_2 emission equivalent reduction would be about 4,841.2 tonnes worth RM 137,974.20.

Table 4.15 displays the potential accruable reduction from the project activity.

Table 4.15: Estimated amount of carbon emission reduction

Year	Estimated carbon emission reduction ($tC0_2$)
1	484.12
2	484.12
3	484.12
4	484.12
5	484.12
6	484.12
7	484.12
8	484.12
9	484.12
10	484.12
Total	**4,841.2**

4.25.7 Investment cost /bill savings and payback period.

Investment cost is the total expenditure spent on the retrofitting. This involves the cost of the T5 bulbs, conversion kits and the labour cost for installation. The current market prize inclusive of discount from lead electrical shops in Malaysia including Wong Lighting Sdn Bhd has been used to estimate the retrofitting cost. The estimated detailed cost of the retrofitting is tabulated in Table 4.16.

Bill savings and payback period are very important interconnected mechanism to ascertain the economic viability of an investment. It is very paramount among other essentials to balance ecological and economic cost.

The annual bill saving due to the retrofitting has been calculated following Saidur and Mahlia, (2011) who have defined savings as:

Annual bill savings = Annual energy saving multiplied by average cost of energy- Equation 7.

Furthermore a conservative assumption of 6% increase of bill rate of electricity per kilowatt in two years has been made. This has been based on the fact that the electricity rate has changed four times with a total increase of almost 35% in five years. Results are illustrated in Table 4.17.

Table 4.16: Investment cost for retrofitting

Description	Quantity	Unit Cost (RM)	Amount (RM)
2 feet T5 14W florescent with conversion kit	479	17.00	8,143.00
4 feet T5 28W florescent with conversion kit	6,109	19.50	119,125.50
Installation	6,588	5.00	32,940
Total			**160,208.5**

Table 4.17: Savings from retrofitting

Year	T5 Annual energy saving (kWh)	Electricity bill rate (RM)	Annual bill saving (RM)
1	176,200	0.312	54.974.40
2	176,200	0.312	54.974.40
3	176,200	0.331	58,322.20
4	176,200	0.331	58,322.20
5	176,200	0.351	61,846.20
6	176,200	0.351	61,846.20
7	176,200	0.372	65,546.40
8	176,200	0.372	65,546.40
9	176,200	0.394	69,422.80
10	176,200	0.394	69,422.80
Total			**620,224.00**

Adapting from Tables 4.16 and 4.17 and applying equation 8 from Saidur et al (2009) who calculated payback time as:

$$\text{Payback period (years)} = \frac{\text{Incremental cost}}{\text{Annual cash savings}} \text{ - Equation 8}$$

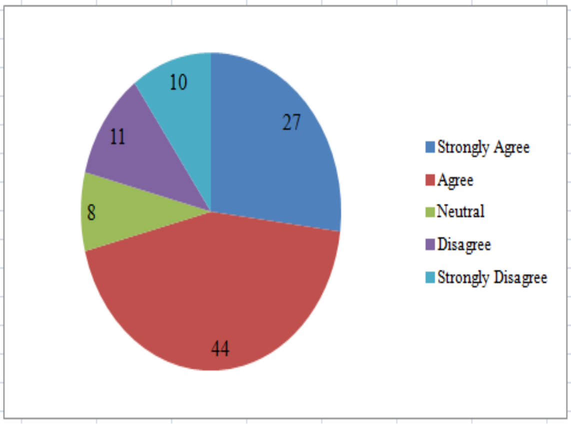
The payback period is less than 3 years. The cost of evaluation and monitoring of a small scale project activity as in Malaysia CDM handbook (2009) by Malaysia Energy Centre is about RM 120,000. It is still worth investing based on total accumulated gain.

4.26 Thermal Comfort in library

To further enhance the case study on the library and explore channels for energy consumption reduction in University of Malaya, a survey on the thermal comfort in the library where an average of about 8% of the university's total population visits the library on daily basis has been conducted.

According to ASHRAE standard 55-2004 thermal comfort is explained as "the condition of mind which expresses satisfaction with the thermal environment". To maintain a constant temperature, there is exchange of heat between the human body and the environment through a blend of conduction, convection, radiation and evaporation (Collins, 2010). He has also pointed out that humidity, air movement, air temperature inclusive of metabolic rate among others influence thermal comfort.

Figure 4.21: Students studying in main library mostly in jackets



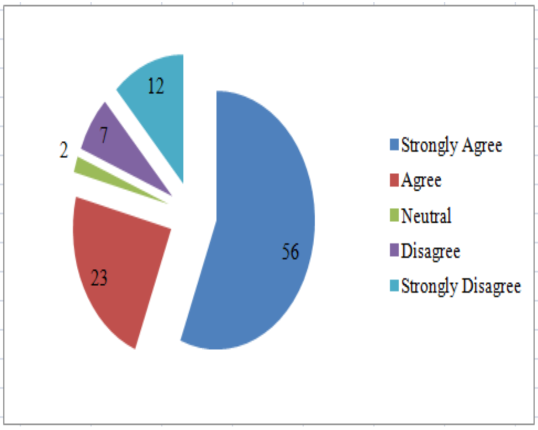


Figure 4.22a: respondents- library is cold   Figure 4.22b: respondents- adjust to warmer

The status quo of the temperature in the library is an average of 24˚Cwhich is due to the government policy of setting thermostat temperature at 24˚C in all government offices except for very sensitive cases, a measure seen as a mechanism to improve energy efficiency and contribute to effort against climate change. 512 people have responded to our questionnaire. Sample of questionnaire is in appendix K.

Figure 4.22a and 4.22b are part of the results, more than ¾ agree the library is cold and thermostat should be adjusted and also about 79% always put on jacket anytime in the library. Figure 4.21 supports this. In two separate researches, a thermal comfort based on an 80% acceptability votes, a temperature of 26˚C and 50-60% humidity was found conducive in the tropics (Yamtraipat et al 2005, Saidur 2009). 80% vote as comfort condition is a standard of measuring thermal comfort zone (ASHRAE standard 55-2004).

Arguments could be the safety of the books based on their hygroscopic nature since they are cellulose based, but record has it that there is relative stability of cellulose at room temperature (Mecklenberg and Tumosa, 1999; Marshallsay and Luxton, 2005). Moreover the Division of library and information services of Florida Department of State has documented that avoidance of fluctuation in temperature and humidity is very essential and furthermore stated that ‘A good rule of the thumb is, if you are sticky, your books are too’.

Lead universities around the world are championing the quest for climate change mitigation through different strategies with energy efficiency as the fulcrum. National University of Singapore as a member of the Global Universities Leaders Forum (GULF) has signed the sustainability campus charter and in its strive to live to expectation has adjusted the average thermostat temperature to 25˚C (NUS, 2012). It has been estimated that a 1˚C reduction in temperature between temperature ranges 22˚C-28˚C will give energy savings of 6% (Yamtraipat et al 2005, Saidur 2009). With a bill saving of 7-10% (Yamtraipat et al 2005), it could generate an economic growth apart from the reduction on environmental footprint that is associated with reduction in the energy consumption.

Using a frugal assumption that the air-conditioning system in the library consumes just 3% more than the lighting (Mahlia, 2011), University of Malaya could save as stipulated in Table 4.18 with an associated carbon footprint reduction of 5,000 tonnes in ten years. This will cost almost nothing to have the quantum savings. 10-30% reduction in GHG emission can be achieved for little or no cost by merely improving energy efficiency (Chan et al., 2007).

Table 4.18: Potential energy saving from thermostat adjustment from 24˚C to 25˚C

Year	Annual energy saving from 1˚C thermostat adjustment (kWh)	Electricity bill rate (RM)	Annual bill saving (RM)
1	212,000	0.312	66,144.00
2	212,000	0.312	66,144.00
3	212,000	0.331	70,172.00
4	212,000	0.331	70,172.00
5	212,000	0.351	74,412.00
6	212,000	0.351	74,412.00
7	212,000	0.372	78,864.00
8	212,000	0.372	78,864.00
9	212,000	0.394	83,528.00
10	212,000	0.394	83,528.00
Total			**746,240.00**

4.27 Waste potential

It is challenging to decouple waste increase with same trend in population. Hence the negative externalities associated with waste continue to increase. Waste management becomes a critical issue as unsustainable waste management constitute among other impacts health and environmental issue. Nowadays waste lots of study have shown that waste could be channeled sustainably especially as renewable fuels however landfilling like in Malaysia take the order of the day. Landfilled waste has a potential of adjacent water pollution which could have health implication to the populace accessing the water or even the ferns and fauna in the region. Many researchers infer that waste exploitation is the best economical strategy for renewable energy production (Kothari et al. 2010). Though it might be difficult to evaluate the cumulative benefit of waste diversion from landfill, it is certain, it cannot to be overemphasized especially with climate change a major issue of concern. CH_4 produced at SWDS continues to be a major concern and is the main contributor to climate change from the waste sector.

University of Malaya with about four tonnes of waste contribution to the landfill daily could be a part contributor to the waste sector climate change impact. Therefore anaerobic digestion is proposed for further exploitation to generate heat and power from the resulting biogas.

Anaerobic digestion is the conversion of organic materials through microbiological reactions in the absence of oxygen (Kothari et al. 2010). Therefore the terminology biogas technology. According to Kotharis et al.(2010) Biogas technology was novel in 1776 when Volta Italian physicist generated methane from organics in bottom sediments of streams.

As the issue of rising waste volume increase globally as other factors including population increase affect it and concern for waste contribution to climate change, several works has been done to convert the waste volume to use.

It is estimated that anaerobic digestion of a tonne of wet organic waste has an energy potential of 600kWh encompassing net capacity of 25-35% of electricity and 50% heat (Banks, 2009; Leffertstra, 2003) and also a digestate of potential viability for utilization in farming. Figure 4.23 shows potentials in biodegradable waste.

The energy content in the biogas due to the digestion and the rate of gas production and total quantity is dependent on the organic composition and the rate it biodegrades (Marcias-Corral et al, 2008). However many works have shown that the biogas content is between 140-250m^3(Bank, 2009; Marcias-Corral et al, 2008). Hence with University of Malaya discharging about 4 tonnes of waste daily in the landfill, a missed context of economic loss to the university and increased contribution to environmental degradation is a case not in contention.

This research is assuming that 30% of the potential 600kWh of energy content in the biogas from the anaerobic digestion is utilized as electricity in University of Malaya through the CHP generation as practiced in several other lead universities. This will result in an average annual energy savings of about 190.7MW (2.5% power generation increase biannually is estimated) over a decade with a corresponding RM67,335 reduction in bill. Table 4.19 showcases the potentials. But it must be noted that a detailed and proper feasibility evaluation must be carried out before embarking on the project. Yet considering the cost of landfilling economically, environmentally like shortening of landfill life span and possible groundwater pollution inclusive of the possible revenue generation from the heat generated from CHP, this project could be conceptualized as viable.

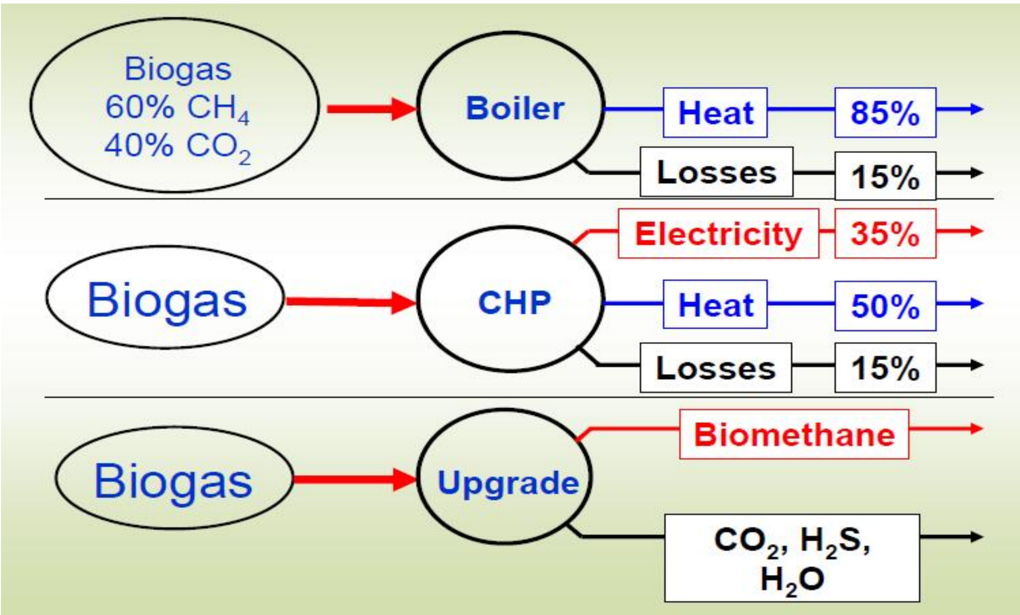


Figure 4.23: Potentials in biogas

Source: Banks, 2009.

Table 4.19: Potentials accruable from power generation using biogas from waste in UM

Year	Annual power generation by CHP (kWh)	Electricity bill rate (RM)	Annual bill saving (RM)
1	181,440.0	0.312	56,609.28
2	181,440.0	0.312	56,609.28
3	185,976.0	0.331	61,558.10
4	185,976.0	0.331	61,558.10
5	190,625.4	0.351	66,909.52
6	190,625.4	0.351	66,909.52
7	195,391.0	0.372	72,685.45
8	195,391.0	0.372	72,685.45
9	200,276.8	0.394	78,909.10
10	200,276.8	0.394	78,909.10

CDM methodology 111.AO./Version 01: Methane recovery through controlled anaerobic digestion has been used to ascertain the potential in emission reduction from the project activity. Equation 9 is applied to estimate the baseline emission:

$BE_y = BE_{SWDS,y} + BE_{ww,y} + BE_{manure,y} - MD_{reg,y} \times GWP_{CH4}$ - Equation 9

WhereBE_y - is the baseline emission in year y

$BE_{SWDS,y}$- The baseline organic waste annual methane generation potential at solid waste disposal site

$BE_{ww,y}$ - Baseline emission calculated based on AMS-111.D for manure co-digested in the project activity.

$BE_{manure,y}$ - Baseline emission calculated with procedure AMS-111.H for project activity co-digested wastewater

$MD_{reg,y}$ -Amount of CH_4 that would have been captured to meet stipulated regulations

GWP_{CH4}- Global warming potential of methane (value-21).

Since $BE_{ww,y} + BE_{manure,y} - MD_{reg,y} \times GWP_{CH4} = 0$ in University Malaya's case

Therefore $BEy = BE_{SWDS,y}$ – Equation 10

Themelis and Ulloa(2007) had estimated that a tonne of waste of 69.6% of biomass material is worth methane biogas of 0.149 tonnes. Consequently evaluation shows potential for carbon emission equivalent reduction of about **1766** tonnes /yr. This is on assumption of 56% potential on the 0.149 tonnes as above and IPCC figure of GWP of CH_4 at 21. The cost savings due to diversion of the waste from the landfill is more than RM400,000 per annum.

4.28 Conclusion for Objective 4: The estimate the potential environmental and economic benefit of greenhouse gases reduction from electricity and waste management in University of Malaya through Certified Emission Reduction:

The objective has been evaluated through the respective applicable methodologies for the electricity and waste as prescribed by the UNFCCC. The CER potential from electricity has been conservatively assessed using the library, which showed a positive potential both environmentally and economically. Figure 4.24 shows a summary of potential benefit, almost RM650, 000.The project activities described could generate CERs of 2250.12 tCO_2e. Waste management is seen as offering a green light if anaerobic digestion with capture of biogas for electricity generation. The potential gain may be more than stated.

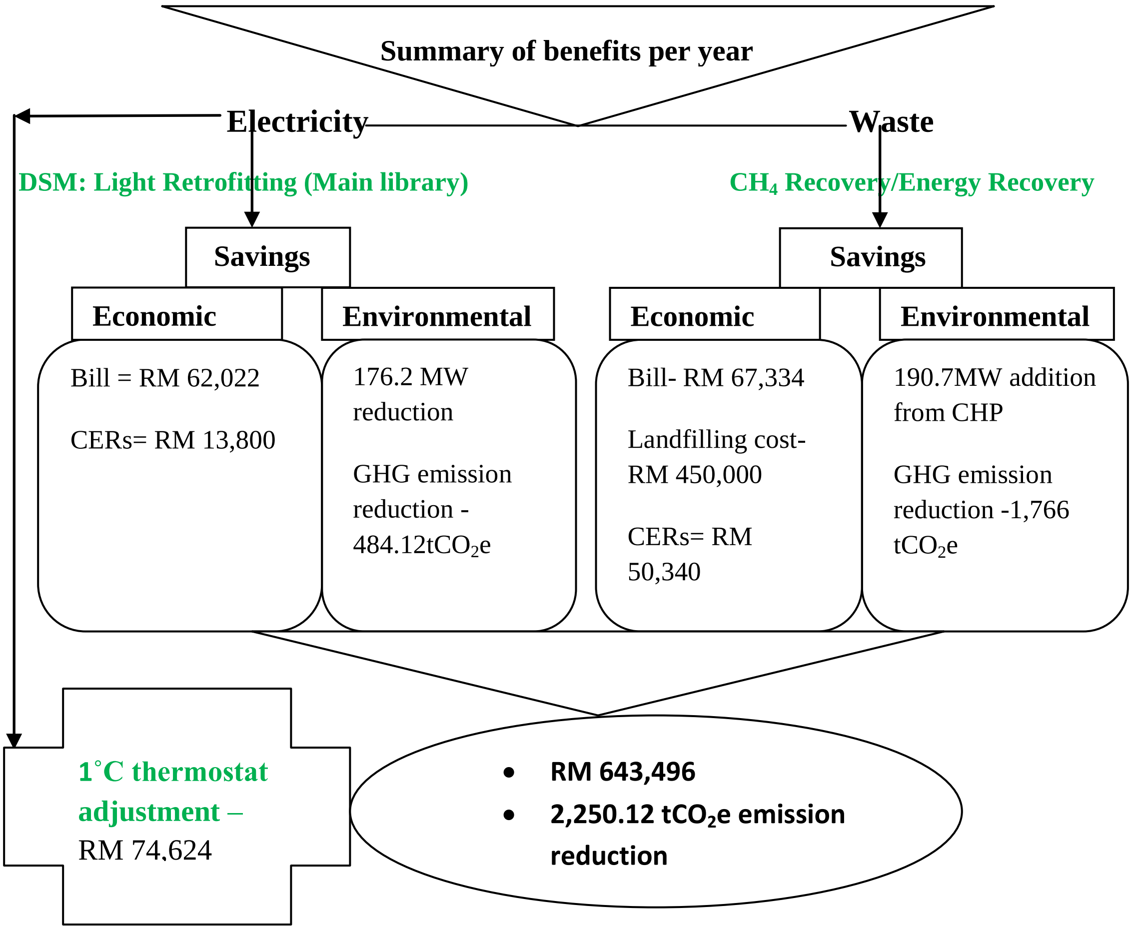


Figure 4.24: Summary of Objective 4

CHAPTER 5

General Discussions

The design of this study was to investigate the Clean Development Mechanism (CDM) assessment potential of University of Malaya as the institution moves on a transition to a low carbon campus. Therefore the focal line for the study is on two principal contributors to climate change in Malaysia, electricity use and the waste management practices. Their contributions in Malaysia are highlighted in the Second National Communication of Malaysia to UNFCCC.

The terminology 'Climate change' is almost a common knowledge presently, though the underlining factors contributing to it still remains far from understanding to quite a number of people. With resource constraint, limited financial power and population increase among other issue facing mankind go on the ascending trend, a modal paradigm shift tend towards conservation, improvement of corporate profile and enhancement of socio-economic status. Competiveness in this 21st century and beyond is the watchword of survival. Globally in the academic circle, publications in global indexed journals remain the biggest indicator considered for global ranking. There is a potential for a little twist to incorporate how the publication are able to affect the ability of the later generation's future not compromised. Prospective college/university students as mentioned earlier currently look into the green profile of institutions which forms part of their key considerations in seeking admittance into them.

The consideration of low carbon campus trickles down due to climate change as there exist underlining potentials in the face of adversities, hence Clean Development Mechanism. This is an underlining carrot which should be taken advantage of especially with University of Malaya well positioned based on the guidelines laid down.

DSM through efficient energy use is very paramount as it forms one of key feasible parameters of CDM assessment. This is necessitated as worldwide mitigation of climate change is a global effort as it requires taken advantage by all and sundry if we must keep the global average temperature increase at less than 2˚C by 2050 to avoid catastrophe, what may be termed environmental and socio-economic thalidomide.

East Asia will experience the highest primary energy demand, with increase of about 300% around 2030 (ADP, 2009), Malaysia that has traditionally been an energy exporter is projected to be a net importer (World Bank, 2010). Energy prices have never been stable. A look at the Tables 4.1-4.5 and 4.8, show the volatility in 6 years, which could have been more but for government continued subsidy. Green budget and tax reforms as currently proposed all over the world may make it very cost ineffective to continue at business as usual as true cost of consumption of environmental perverse goods and services will be too exorbitant for most establishment to bear. University of Malaya is to be autonomous in about 2 years hence this study.

Having outlined these side tracks as a refresher, we have carried out this study in University of Malaya to be logically armed with the externalities and potentials associated with the heavily fossil fuel dependent energy consumption and waste practices. This will serve as a vital enlightening tool for policy formulation leading to a low carbon campus community and as a result tap on the accruing benefits of the sustainable part in the form of expanded corporate status of trading in carbon credit.

The study has empowered us with an estimated perceptive stance on the potential environmental burden due to human activities in University of Malaya. Apparently necessity abide in a concise review of the trend in Malaysia and recommend yielding alternatives that could boost a quicker, firm and long lasting transition to a low carbon economy and ensure the feasibility of trading in the carbon market as the case of University of Malaya applies.

Electricity consumption in Malaysia continues to rise and could be increasing more than the GDP. In 2004 gross domestic product (GDP) growth was 7.5% which was almost 22% short of the electricity growth rate (Pusat Tenaga Malaysia, 2004; Chandran et al, 2010). Final energy demand is estimated to reach 116 mega tonne of oil equivalent by 2020 on an annual growth rate of 8.1% (Chandran et al, 2010) and Malaysia among the ASEAN nations has one of the highest electricity intensity year on year (Pusat Tenaga Malaysia, 2004). It is no longer news that over the years Malaysia energy consumption has been at least 90% dependent on fossil fuel. Externalities associated with this could be enormous. Khazanah Nasional (2010) stated that in 2008 Malaysia was second in global CO_2 emission growth rate and total emission by 2020 if business as usual goes on could hit about 75% more than 2005 figure. Climate change has a proportional relationship with this.

Therefore from the perspective of University of Malaya which serves as a representative community with a high potential for extrapolation, some inefficiencies are highlighted;

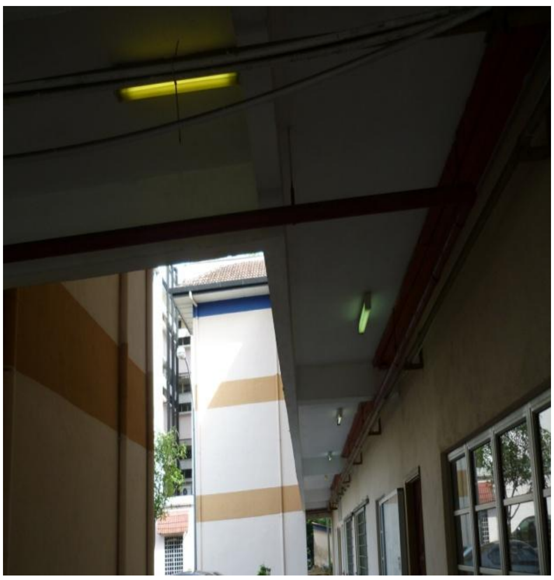


Figure 4.20a Poor lighting management in ISB

Figure 4.20b Ground floor UM main library

Figure 4.20c: Poor utilization of day lighting in main library.

Figure 4.20d: Poor utilization of day lighting in main library.

Figure 4.20e: Poor utilization of day lighting at new R and D building

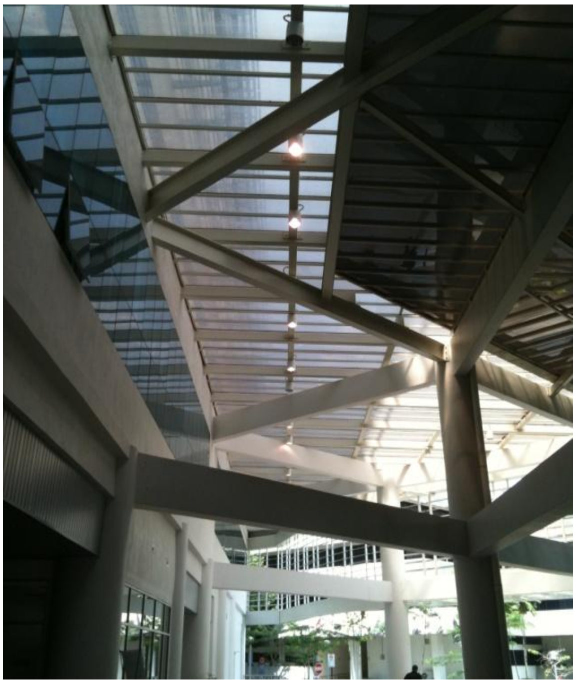


Figure 4.20f: Poor utilization of day lighting at new R and D building

Figure 4.20g: Poor utilization of day lighting at new R and D building

Figure 4.20h: Poor utilization of day lighting at new R and D building

Figure 4.20a shows electricity misuse at the Institute of Biological Science (ISB). This two storey building is situated adjacent to the Department of Chemistry. It is equipped with about 55 number 18W T8 florescent lamps at the corridors and convenient rooms on the 3 floors with the corridors lamps supposed to act as security lighting, however, all the lights were left on for about 90 hours (January 25-29, 2013) during the last public holiday that stretched over the weekend. This would have cost the university and extra avoidable bill of RM 14 with associated ecological footprint of 0.12 tonnes of carbon equivalent emission.

Figures 4.20b, 4.20c and 4.20d show part of why the university's energy bill continue to rise; Figure 4.20b which is on ground floor of main library may look aesthetically okay but measurements proved it was over lighted at 421lx about 70% more than recommended intensity, while figures 4.20c and 4.20d show part of 4th floor of the library. Here inefficiency in utilization of natural lighting is showcased. Measurement using a lux meter indicated light intensity of 960lx which was 284% more than the recommended light intensity in library of 250lx.

Figures 4.20e-h highlight the situation at the new R and D building besides the IPS building. It is obvious that at about 2pm when the pictures were taken, there was no need for the lights to be on. No matter how efficient a lamp might be, it is sure that a light that is on is like a metered taxi in operation.

Waste deposition at the landfill is no doubt also of great concern in Malaysia where more than 90% of waste is landfilled creating more need for the already scarce land apart from its environmental issue of possible ground water pollution and more.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

This study explains the trend of electricity consumption and the corresponding emission in University of Malaya over the last 6 years. This is alongside the waste practices in parallel with the potential gain accruable to the institution through CDM as it transits to a low carbon campus. Consequently the results conclude as follows:

- Most electricity end use technologies in University of Malaya are energy inefficient and electricity consumption in University of Malaya is not adequately monitored. In an interview with one of the lead officers of the department in JPPHB responsible for receipt of electricity from TNB, stepping down and transmission to the downstream, it was surprising that the reason why there are no dedicated meters which could be key performance indicators in various faculties and institutes was because they are seen purely part of University of Malaya, hence whatever they consume was not necessary to be identified as the cumulative final consumption and bill was what mattered. Furthermore the issue of concern about electricity was only noted after the Government Policy of standard 24˚C in all offices, but no serious short term implementable policies off this central point has been structured to bridge the gap between existing and potential that could result from possible long road map from the inaugurated Low Carbon Committee.
- The capacity of the waste management is quite poor, although the Zero Waste Campaign and UMCARES are on the right track towards a more sustainable waste management, the attention of top management is not encouraging ranging from provision of a micro space of operation to non provision of the technology to better handle the waste, instead more than RM400,000 is spent yearly in

contribution to the degradation of the environment which is already in a deficit status. This is also a contribution to reduction in quality of life as quality of life on earth has an intrinsic relationship with general environmental quality (Vidali, 2001; McMichael, 2009). Evidences are obvious of the deteriorating integrity of the earth from human demands which is already over its natural capability to provide, sop up and replenish (McMichael, 2009).

- From the ground assessments of the two main issues discussed earlier there are promising opportunities for University of Malaya to participate in CDM project activities.

The conclusion drawn from this study has enabled making the following recommendations:

Lighting

- Replacement of inefficient lighting with efficient technology as shown in the library case study.
- Installation of occupancy sensor so that occupancy load determines lighting thereby energy could be saved.
- Installation of sensors on security light instead of timers so that the natural light intensity directly affects the lighting operation.
- Decentralization of switches so that only lights needed is put on instead of switching on with many light while few lighting are used.
- Lighting standard set by the American National Safety Institute (ANSI) of 500, 500, 750, 250, and 150 lux, for offices, laboratories, workshops, classrooms, and corridors respectively should be applied (Alajmi, 2012)
- Day lighting should be utilized.

- In each Faculty or Institute, someone should be assigned the responsibility of ensuring the integrity of lighting.

Air conditioning

- Adjustment of thermostat set point by 1˚Cwhich could save at least 6% of energy.
- Installation of appropriate vents commensurate with the size of the carrels.
- Constant monitoring of the humidity in the library, making sure the Air Handling Unit (AHU) is in good standard condition to avoid epileptic situation that could impact the books.

General

- As concern for the future of the social, environmental and economic indebted globe continues to deepen, only sectors that remain competitive will be able to survive in decades to come. A culture of sustainable consciousness should be fastened in the fabric of University Malaya. There is a potential of 6% energy saving if behavioural lever is correctly aligned adequately (Khazanah Nasional, 2010). Many lead universities including National University of Singapore are building curricula that incorporates sustainability. A shift away by any establishment from improving its environmental footprint could place it on radar of suspect, drastic reduction in patronage with a synchronization of unacceptability. Most lead universities make it a point that every admitted student would pass through a course on sustainable living which is also graded. UM should incorporate this.
- Presently UMCARES, Zero Waste Campaign and the Low Carbon Campus committee are the fulcrum on which the transition to a low carbon campus is

hinged; therefore it becomes very essential for the management to encourage them more with all necessary support for capacity building.

- University of Malaya should install dedicated meters in all the buildings to enhance benchmarking for performance. This could be an aspect of key performance indicator. The importance of KPI is emphasized by Velimirovic et al(2011) that: "... KPI tells you where performance has been in the past, where it is now, and perhaps more useful, where performance is likely to be in the future"
- It should critically consider energy auditing of old existing building following ASHRAE-100 (2006) energy audit standard, as it has been shown to result in huge energy reduction (Almaji, 2012; Escrivá-Escrivá, et al., 2010; Rahman, 2010),.
- The institution continues to add new building, to further enhance the aim of a low carbon campus, consideration should be given to building Net-Zero Buildings (NZEBs) or nearly Net Zero Building (nNZEB). These are buildings that annually are able to produce energy sourced from renewable that are enough or nearly enough with the energy consumption capacity of the building (Almaji, 2012). These and more could equip University of Malaya to get more recognition in the global carbon market.
- Furthermore as part of the recommendation, University of Malaya should gear towards joining the Global Universities Leaders Forum (GULF) and sign the sustainability charter, by being part of this organisation which National University of Singapore is part of, the institution could network easily with other lead universities in sustainability ventures and further inscribe UM's effort in easing environmental burden in the global sand of time.

Finally an average of 74,000MW is consumed in UM per annum. Source of power is over 90% fossil. About 4 tonnes of biodegradable waste is sent to landfill daily. Consequently about 210,000 tCO_2e and 1,750 tCO_2e could have been emitted yearly from electricity and biodegradable waste respectively. As for UM eligibility for CDM, the case study of the main library shows a potential to embark into CDM project activities. The project activities could generate CERs of 2250.12 tCO_2e. Estimation shows a cumulative potential annual benefit of RM 650,000. Therefore potential avails for UM to integrate the recommendations in policy making and implementation. University Teknologi Malaysia (UTM) sustainable energy management programme has embarked on energy saving projects including lighting retrofitting. The institution made a saving of RM 2.5 million in 2011 (UTM website, 2013). Their electricity consumption has reduced by over 11% as against 2009 figure. Therefore implementation of the recommendations offers a win-win situation. Since autonomy requires financial stability, UM should take advantage of the potentials that exist. This would not only boost the financial status of the university. There will be reduction of the ecological footprint of this community; while increasing the global footprint as an environmentally responsible institution.

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APPENDICE

Appendix A; Electricity Consumption in UM main campus, 2007

PENGGUNAAN ELEKTRIK KAMPUS UM 2007

Bulan	Penggunaan (KWh)	Kadar	Amaun (RM)	Max Demand (KWh)	Kadar	Amaun (RM)	Jumlah Caj Bulanan (RM)	Jumlah Di Bil (RM) (diskaun 10%)
Jan-07	**6,263,961.00**	0.234	1,465,766.87	18,185.00	19.50	354,607.50	1,820,374.37	**1,638,336.94**
Feb-07	**5,250,423.00**	0.234	1,228,598.98	17,941.00	19.50	349,849.50	1,578,448.48	**1,420,603.63**
Mar-07	**6,781,967.00**	0.234	1,586,980.28	19,102.00	19.50	372,489.00	1,959,469.28	**1,763,522.35**
Apr-07	**5,972,777.00**	0.234	1,397,629.82	17,723.00	19.50	345,598.50	1,743,228.32	**1,568,905.49**
May-07	**5,622,615.00**	0.234	1,315,691.91	15,711.00	19.50	306,364.50	1,622,056.41	**1,459,850.77**
Jun-07	**5,622,615.00**	0.234	1,315,691.91	15,713.00	19.50	306,403.50	1,622,095.41	**1,459,885.87**
Jul-07	**5,622,615.00**	0.234	1,315,691.91	18,567.00	19.50	362,056.50	1,677,748.41	**1,509,973.57**
Aug-07	**6,699,706.00**	0.234	1,567,731.20	18,700.00	19.50	364,650.00	1,932,381.20	**1,739,143.08**
Sep-07	**6,522,597.00**	0.234	1,526,287.70	18,647.00	19.50	363,616.50	1,889,904.20	**1,700,913.78**
Oct-07	**5,588,241.00**	0.234	1,307,648.39	18,091.00	19.50	352,774.50	1,660,422.89	**1,494,380.60**
Nov-07	**5,662,439.00**	0.234	1,325,010.73	15,536.00	19.50	302,952.00	1,627,962.73	**1,465,166.45**
Dec-07	**5,116,970.00**	0.234	1,197,370.98	16,386.00	19.50	319,527.00	1,516,897.98	**1,365,208.18**

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Appendix B: Electricity Consumption in UM main campus, 2008

PENGGUNAAN ELEKTRIK KAMPUS UM 2008

Bulan	Penggunaan (KWh)	Kadar	Amaun (RM)	Max Demand (KWh)	Kadar	Amaun (RM)	Jumlah Caj Bulanan (RM)	Jumlah Di Bil (RM) (diskaun 10%)
Jan-08	**6,319,143.00**	0.234	1,478,679.46	18,390.00	19.50	358,605.00	1,837,284.46	**1,653,556.02**
Feb-08	**5,739,516.00**	0.234	1,343,046.74	18,337.00	19.50	357,571.50	1,700,618.24	**1,530,556.42**
Mar-08	**6,413,342.00**	0.234	1,500,722.03	18,488.00	19.50	360,516.00	1,861,238.03	**1,675,114.23**
Apr-08	**6,430,288.00**	0.234	1,504,687.39	18,660.00	19.50	363,870.00	1,868,557.39	**1,681,701.65**
May-08	**5,867,043.00**	0.234	1,372,888.06	16,854.00	19.50	328,653.00	1,701,541.06	**1,531,386.96**
Jun-08	**5,450,237.00**	0.234	1,275,355.46	15,847.00	19.50	309,016.50	1,584,371.96	**1,425,934.76**
Jul-08	**6,625,358.00**	**0.296**	1,961,105.97	18,751.00	**24.600**	461,274.60	2,422,380.57	**2,180,142.51**
Aug-08	**6,481,912.00**	0.296	1,918,645.95	19,079.00	24.600	469,343.40	2,387,989.35	**2,149,190.42**
Sep-08	**5,912,520.00**	0.296	1,750,105.92	17,786.00	24.600	437,535.60	2,187,641.52	**1,968,877.37**
Oct-08	**5,952,164.00**	0.296	1,761,840.54	17,704.00	24.600	435,518.40	2,197,358.94	**1,977,623.05**
Nov-08	**5,750,354.00**	0.296	1,702,104.78	16,734.00	24.600	411,656.40	2,113,761.18	**1,902,385.07**
Dec-08	**5,244,557.00**	0.296	1,552,388.87	15,954.00	24.600	392,468.40	1,944,857.27	**1,750,371.54**

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Appendix C: Electricity Consumption in UM main campus, 2009

PENGGUNAAN ELEKTRIK KAMPUS UM 2009

Bulan	Penggunaan (KWh)	Kadar	Amaun (RM)	Max Demand (KWh)	Kadar	Amaun (RM)	Jumlah Caj Bulanan (RM)	Jumlah Di Bil (RM) (diskaun 10%)
Jan-09	**5,664,663.00**	0.296	1,676,740.25	17,564.00	24.600	432,074.40	2,108,814.65	**1,897,933.18**
Feb-09	**5,676,227.00**	0.296	1,680,163.19	19,148.00	24.600	471,040.80	2,151,203.99	**1,936,083.59**
Mar-09	**6,614,802.00**	**0.288**	1,905,062.98	19,111.00	**23.930**	457,326.23	2,362,389.21	**2,126,150.29**
Apr-09	**6,635,866.00**	0.288	1,911,129.41	18,653.00	23.930	446,366.29	2,357,495.70	**2,121,746.13**
May-09	**5,974,287.00**	0.288	1,720,594.66	16,881.00	23.930	403,962.33	2,124,556.99	**1,912,101.29**
Jun-09	**5,750,205.00**	0.288	1,656,059.04	16,443.00	23.930	393,480.99	2,049,540.03	**1,844,586.03**
Jul-09	**6,706,469.00**	0.288	1,931,463.07	18,701.00	23.930	447,514.93	2,378,978.00	**2,141,080.20**
Aug-09	**6,402,257.00**	0.288	1,843,850.02	19,295.00	23.930	461,729.35	2,305,579.37	**2,075,021.43**
Sep-09	**5,595,287.00**	0.288	1,611,442.66	18,324.00	23.930	438,493.32	2,049,935.98	**1,844,942.38**
Oct-09	**6,745,121.00**	0.288	1,942,594.85	18,375.00	23.930	439,713.75	2,382,308.60	**2,144,077.74**
Nov-09	**5,505,244.00**	0.288	1,585,510.27	16,978.00	23.930	406,283.54	1,991,793.81	**1,792,614.43**
Dec-09	**5,737,224.00**	0.288	1,652,320.51	16,804.00	23.930	402,119.72	2,054,440.23	**1,848,996.21**

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Appendix D: Electricity Consumption in UM main campus, 2010

PENGGUNAAN ELEKTRIK KAMPUS UM 2010

Bulan	Penggunaan (KWh)	Kadar	Amaun (RM)	Max Demand (KWh)	Kadar	Amaun (RM)	Jumlah Caj Bulanan (RM)	Diskaun 10% TNB	Jumlah Setelah Diskaun 10% TNB	Kumpulan Wang Tenaga Baru	Jumlah Di Bil (RM)
Jan-10	**6,402,990.00**	0.288	1,844,061.12	18,715.00	23.930	447,849.95	2,291,911.07	229,191.11	**2,062,719.96**	20,627.20	2,083,347.16
Feb-10	**5,764,570.00**	0.288	1,660,196.16	20,147.00	23.930	482,117.71	2,142,313.87	214,231.39	**1,928,082.48**	19,280.82	1,947,363.31
Mar-10	**7,503,540.00**	0.288	2,161,019.52	20,329.00	23.930	486,472.97	2,647,492.49	264,749.25	**2,382,743.24**	23,827.43	2,406,570.67
Apr-10	**6,879,008.00**	0.288	1,981,154.30	19,581.00	23.930	468,573.33	2,449,727.63	244,972.76	**2,204,754.87**	22,047.55	2,226,802.42
May-10	**6,169,052.00**	0.288	1,776,686.98	17,575.00	23.930	420,569.75	2,197,256.73	219,725.67	**1,977,531.05**	19,775.31	1,997,306.36
Jun-10	**5,899,074.00**	0.288	1,698,933.31	16,561.00	23.930	396,304.73	2,095,238.04	209,523.80	**1,885,714.24**	18,857.14	1,904,571.38
Jul-10	**6,596,986.00**	0.288	1,899,931.97	19,230.00	23.930	460,173.90	2,360,105.87	236,010.59	**2,124,095.28**	21,240.95	2,145,336.23
Aug-10	**6,781,763.00**	0.288	1,953,147.74	19,420.00	23.930	464,720.60	2,417,868.34	241,786.83	**2,176,081.51**	21,760.82	2,197,842.32
Sep-10	**5,418,823.00**	0.288	1,560,621.02	18,723.00	23.930	448,041.39	2,008,662.41	200,866.24	**1,807,796.17**	18,077.96	1,825,874.13
Oct-10	**6,835,995.00**	0.288	1,968,766.56	19,166.00	23.930	458,642.38	2,427,408.94	242,740.89	**2,184,668.05**	21,846.68	2,206,514.73
Nov-10	**5,729,879.00**	0.288	1,650,205.15	16,745.00	23.930	400,707.85	2,050,913.00	205,091.30	**1,845,821.70**	18,458.22	1,864,279.92
Dec-10	**5,780,791.00**	0.288	1,664,867.81	16,599.00	23.930	397,214.07	2,062,081.88	206,208.19	**1,855,873.69**	18,558.74	1,874,432.43

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Appendix E: Electricity Consumption in UM main campus, 2011

PENGGUNAAN ELEKTRIK KAMPUS UM 2011

Bulan	Penggunaan (KWh)	Kadar	Amaun (RM)	Max Demand (KWh)	Kadar	Amaun (RM)	Jumlah Caj Bulanan (RM)	Diskaun 10% TNB	Jumlah Setelah Diskaun 10% TNB	Kumpulan Wang Tenaga Baru	Jumlah Di Bil (RM)
Jan-11	6,170,929.00	0.288	1,777,227.55	18,593.00	23.930	444,930.49	2,222,158.04	222,215.80	1,999,942.24		1,999,942.24
Feb-11	5,573,081.00	0.288	1,605,047.33	19,824.00	23.930	474,388.32	2,079,435.65	207,943.56	1,871,492.08		1,871,492.08
Mar-11	6,964,813.00	0.288	2,005,866.14	19,695.00	23.930	471,301.35	2,477,167.49	247,716.75	2,229,450.74		2,229,450.74
Apr-11	6,590,260.00	0.288	1,897,994.88	19,428.00	23.930	464,912.04	2,362,906.92	236,290.69	2,126,616.23		2,126,616.23
May-11	6,231,869.00	0.288	1,794,778.27	17,501.00	23.930	418,798.93	2,213,577.20	221,357.72	1,992,219.48		1,992,219.48
Jun-11	6,085,579.00	0.312	1,898,700.65	16,665.00	25.900	431,623.50	2,330,324.15	233,032.41	2,097,291.73		2,097,291.73
Jul-11	6,145,705.00	0.312	1,917,459.96	17,706.00	25.900	458,585.40	2,376,045.36	237,604.54	2,138,440.82		2,138,440.82
Aug-11	5,586,381.00	0.312	1,742,950.87	16,262.00	25.900	421,185.80	2,164,136.67	216,413.67	1,947,723.00		1,947,723.00
Sep-11	6,526,857.00	0.312	2,036,379.38	20,953.00	25.900	542,682.70	2,579,062.08	257,906.21	2,321,155.88		2,321,155.88
Oct-11	7,088,452.00	0.312	2,211,597.02	20,940.00	25.900	542,346.00	2,753,943.02	275,394.30	2,478,548.72		2,478,548.72
Nov-11	6,364,471.00	0.312	1,985,714.95	18,976.00	25.900	491,478.40	2,477,193.35	247,719.34	2,229,474.02		2,229,474.02
Dec-11	6,699,309.00	0.312	2,090,184.41	19,099.00	25.900	494,664.10	2,584,848.51	258,484.85	2,326,363.66	23,263.64	2,349,627.29

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Appendix F: Electricity Consumption in UM main campus, 2012.

PENGGUNAAN ELEKTRIK KAMPUS UM 2012

Bulan	Penggunaan (KWh)	Kadar	Amaun (RM)	Max Demand (KWh)	Kadar	Amaun (RM)	Jumlah Caj Bulanan (RM)	Diskaun 10% TNB	Jumlah Setelah Diskaun 10% TNB	Kumpulan Wang Tenaga Baru	Jumlah Di Bil (RM)
Jan-12	**6,121,706.00**	0.312	1,909,972.27	18,900.00	25.900	489,510.00	2,399,482.27	239,948.23	**2,159,534.04**	21,595.34	2,181,129.39
Feb-12	**6,127,836.00**	0.312	1,911,884.83	19,374.00	25.900	501,786.60	2,413,671.43	241,367.14	**2,172,304.29**	21,723.04	2,194,027.33
Mar-12	**7,196,681.00**	0.312	2,245,364.47	20,347.00	25.900	526,987.30	2,772,351.77	277,235.18	**2,495,116.59**	24,951.17	2,520,067.76
Apr-12	**6,865,963.00**	0.312	2,142,180.46	20,612.00	25.900	533,850.80	2,676,031.26	267,603.13	**2,408,428.13**	24,084.28	2,432,512.41
May-12	**7,527,095.00**	0.312	2,348,453.64	21,339.00	25.900	552,680.10	2,901,133.74	290,113.37	**2,611,020.37**	26,110.20	2,637,130.57
Jun-12	**6,962,268.00**	0.312	2,172,227.62	19,390.00	25.900	502,201.00	2,674,428.62	267,442.86	**2,406,985.75**	24,069.86	2,431,055.61
Jul-12	**6,303,064.00**	0.312	1,966,555.97	17,599.00	25.900	455,814.10	2,422,370.07	242,237.01	**2,180,133.06**	21,801.33	2,201,934.39
Aug-12	**5,419,934.00**	0.312	1,691,019.41	16,873.00	25.900	437,010.70	2,128,030.11	212,803.01	**1,915,227.10**	19,152.27	1,934,379.37
Sep-12	**6,696,188.00**	0.312	2,089,210.66	20,785.00	25.900	538,331.50	2,627,542.16	262,754.22	**2,364,787.94**	23,647.88	2,388,435.82
Oct-12	**7,385,222.00**	0.312	2,304,189.26	20,945.00	25.900	542,475.50	2,846,664.76	284,666.48	**2,561,998.29**	25,619.98	2,587,618.27
Nov-12	**6,685,740.00**	0.312	2,085,950.88	20,691.00	25.900	535,896.90	2,621,847.78	262,184.78	**2,359,663.00**	23,596.63	2,383,259.63
Dec-12	**6,873,515.00**	0.312	2,144,536.68	19,709.00	25.900	510,463.10	2,654,999.78	265,499.98	**2,389,499.80**	23,895.00	2,413,394.80

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Appendix G: Electricity Consumption in UM main campus Residential College 2009

PENGGUNAAN ELEKTRIK ASRAMA UM 2009

Asrama	Januari			Februari			Mac			April			Mei			Jun		
	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)
Asrama Pertama (1)	**34,625.00**	0.383	13,261.38	**47,822.00**	0.383	18,315.83	**62,150.00**	0.370	22,995.50	**57,163.00**	0.370	21,150.31	**29,394.00**	0.370	10,875.78	**33,039.00**	0.397	13,116.48
Asrama Kedua (2)	**45,852.00**	0.383	17,561.32	**52,383.00**	0.383	20,062.69	**72,697.00**	0.370	26,897.89	**69,782.00**	0.370	25,819.34	**46,383.00**	0.370	17,161.71	**63,926.00**	0.397	25,378.62
Asrama Ketiga (3)	**67,102.00**	0.383	25,700.07	**89,807.00**	0.383	34,396.08	**125,519.00**	0.370	46,442.03	**111,686.00**	0.370	41,323.82	**62,357.00**	0.370	23,072.09	**44,936.00**	0.397	17,839.59
Asrama Keempat (4)	**41,812.00**	0.383	16,014.00	**35,818.00**	0.383	13,718.29	**51,753.00**	0.370	19,148.61	**65,306.00**	0.370	24,163.22	**39,632.00**	0.370	14,663.84	**32,233.00**	0.397	12,796.50
Asrama Kelima (5)	**27,366.00**	0.383	10,481.18	**24,577.00**	0.383	9,412.99	**33,848.00**	0.370	12,523.76	**43,145.00**	0.370	15,963.65	**25,920.00**	0.370	9,590.40	**17,419.00**	0.397	6,915.34
Asrama Keenam (6)	**57,017.00**	0.383	21,837.51	**70,025.00**	0.383	26,819.58	**96,842.00**	0.370	35,831.54	**84,697.00**	0.370	31,337.89	**63,392.00**	0.370	23,455.04	**82,952.00**	0.397	32,931.94
Asrama Ketujuh (7)	**51,341.00**	0.383	19,663.60	**48,508.00**	0.383	18,578.56	**67,556.00**	0.370	24,995.72	**83,940.00**	0.370	31,057.80	**38,431.00**	0.370	14,219.47	**25,575.00**	0.397	10,153.28
Asrama Kelapan (8)	**61,696.00**	0.383	23,629.57	**84,627.00**	0.383	32,412.14	**119,397.00**	0.370	44,176.89	**108,424.00**	0.370	40,116.88	**72,508.00**	0.370	26,827.96	**45,415.00**	0.397	18,029.76
Asrama Kesepuluh (10)	**40,756.00**	0.383	15,609.55	**51,788.00**	0.383	19,834.80	**70,148.00**	0.370	25,954.76	**67,291.00**	0.370	24,897.67	**39,520.00**	0.370	14,622.40	**29,610.00**	0.397	11,755.17
Asrama Kesebelas (11)	**70,678.00**	0.383	27,069.67	**57,984.00**	0.383	22,207.87	**86,072.00**	0.370	31,846.64	**103,154.00**	0.370	38,166.98	**59,653.00**	0.370	22,071.61	**54,651.00**	0.397	21,696.45
Asrama Keduabelas (12)	**193,947.00**	0.383	74,281.70	**170,769.00**	0.383	65,404.53	**223,431.00**	0.370	82,669.47	**338,088.00**	0.370	125,092.56	**121,027.00**	0.370	44,779.99	**174,964.00**	0.397	69,460.71

Asrama	Julai			Ogos			September			Oktober			November			Disember		
	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)
Asrama Pertama (1)	**48,329.00**	0.397	19,186.61	**42,877.00**	0.397	17,022.17	**44,073.00**	0.397	17,496.98	**66,963.00**	0.397	26,584.31	**117,880.00**	0.397	46,798.36	**35,331.00**	0.397	14,026.41
Asrama Kedua (2)	**63,531.00**	0.397	25,221.81	**53,927.00**	0.397	21,409.02	**58,577.00**	0.397	23,255.07	**57,106.00**	0.397	22,671.08	**56,417.00**	0.397	22,397.55	**38,805.00**	0.397	15,405.59
Asrama Ketiga (3)	**66,793.00**	0.397	26,516.82	**53,561.00**	0.397	21,263.72	**77,409.00**	0.397	30,731.37	**116,725.00**	0.397	46,339.83	**71,860.00**	0.397	28,528.42	**78,690.00**	0.397	31,239.93
Asrama Keempat (4)	**60,830.00**	0.397	24,149.51	**47,965.00**	0.397	19,042.11	**43,486.00**	0.397	17,263.94	**46,537.00**	0.397	18,475.19	**46,537.00**	0.397	18,475.19	**36,061.00**	0.397	14,316.22
Asrama Kelima (5)	**40,505.00**	0.397	16,080.49	**32,661.00**	0.397	12,966.42	**28,188.00**	0.397	11,190.64	**36,369.00**	0.397	14,438.49	**36,369.00**	0.397	14,438.49	**43,601.00**	0.397	17,309.60
Asrama Keenam (6)	**83,453.00**	0.397	33,130.84	**71,211.00**	0.397	28,270.77	**85,076.00**	0.397	33,775.17	**84,730.00**	0.397	33,637.81	**66,676.00**	0.397	26,470.37	**70,025.00**	0.397	27,799.93
Asrama Ketujuh (7)	**73,202.00**	0.397	29,061.19	**55,510.00**	0.397	22,037.47	**49,340.00**	0.397	19,587.98	**54,823.00**	0.397	21,764.73	**54,823.00**	0.397	21,764.73	**47,958.00**	0.397	19,039.33
Asrama Kelapan (8)	**83,216.00**	0.397	33,036.75	**65,348.00**	0.397	25,943.16	**99,362.00**	0.397	39,446.71	**43,939.00**	0.397	17,443.78	**65,993.00**	0.397	26,199.22	**47,975.00**	0.397	19,046.08
Asrama Kesepuluh (10)	**56,575.00**	0.397	22,460.28	**45,761.00**	0.397	18,167.12	**63,971.00**	0.397	25,396.49	**68,111.00**	0.397	27,040.07	**48,928.00**	0.397	19,424.42	**34,906.00**	0.397	13,857.68
Asrama Kesebelas (11)	**100,647.00**	0.397	39,956.86	**80,018.00**	0.397	31,767.15	**68,360.00**	0.397	27,138.92	**87,701.00**	0.397	34,817.30	**60,161.00**	0.397	23,883.92	**78,633.00**	0.397	31,217.30
Asrama Keduabelas (12)	**285,852.00**	0.397	113,483.24	**237,822.00**	0.397	94,415.33	**188,994.00**	0.397	75,030.62	**255,122.00**	0.397	101,283.43	**164,869.00**	0.397	65,452.99	**258,158.00**	0.397	102,488.73

Appendix H: Electricity Consumption in UM main campus Residential College 2010

PENGGUNAAN ELEKTRIK ASRAMA UM 2010

Asrama	Januari			Februari			Mac			April			Mei			Jun		
	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)
Asrama Pertama (1)	**70,819.00**	0.397	28,115.14	**36,824.00**	0.397	14,619.13	**56,362.00**	0.397	22,375.71	**80,674.00**	0.397	32,027.58	**40,712.00**	0.397	16,162.66	**23,898.00**	0.397	9,487.51
Asrama Kedua (2)	**71,854.00**	0.397	28,526.04	**38,091.00**	0.397	15,122.13	**83,218.00**	0.397	33,037.55	**98,958.00**	0.397	39,286.33	**59,244.00**	0.397	23,519.87	**44,723.00**	0.397	17,755.03
Asrama Ketiga (3)	**113,176.00**	0.397	44,930.87	**66,877.00**	0.397	26,550.17	**111,949.00**	0.397	44,443.75	**127,671.00**	0.397	50,685.39	**74,263.00**	0.397	29,482.41	**62,375.00**	0.397	24,762.88
Asrama Keempat (4)	**53,594.00**	0.397	21,276.82	**45,848.00**	0.397	18,201.66	**45,160.00**	0.397	17,928.52	**54,305.00**	0.397	21,559.09	**44,700.00**	0.397	17,745.90	**45,786.00**	0.397	18,177.04
Asrama Kelima (5)	**51,203.00**	0.397	20,327.59	**38,684.00**	0.397	15,357.55	**38,871.00**	0.397	15,431.79	**62,084.00**	0.397	24,647.35	**50,442.00**	0.397	20,025.47	**28,409.00**	0.397	11,278.37
Asrama Keenam (6)	**63,576.00**	0.397	25,239.67	**47,834.00**	0.397	18,990.10	**79,049.00**	0.397	31,382.45	**98,656.00**	0.397	39,166.43	**60,090.00**	0.397	23,855.73	**50,509.00**	0.397	20,052.07
Asrama Ketujuh (7)	**72,641.00**	0.397	28,838.48	**56,088.00**	0.397	22,266.94	**53,178.00**	0.397	21,111.67	**85,131.00**	0.397	33,797.01	**49,044.00**	0.397	19,470.47	**44,160.00**	0.397	17,531.52
Asrama Kelapan (8)	**43,908.00**	0.397	17,431.48	**44,099.00**	0.397	17,507.30	**54,676.00**	0.397	21,706.37	**103,003.00**	0.397	40,892.19	**55,497.00**	0.397	22,032.31	**56,428.00**	0.397	22,401.92
Asrama Kesepuluh (10)	**72,237.00**	0.397	28,678.09	**42,668.00**	0.397	16,939.20	**71,822.00**	0.397	28,513.33	**86,026.00**	0.397	34,152.32	**46,522.00**	0.397	18,469.23	**41,222.00**	0.397	16,365.13
Asrama Kesebelas (11)	**63,268.00**	0.397	25,117.40	**93,490.00**	0.397	37,115.53	**64,090.00**	0.397	25,443.73	**104,616.00**	0.397	41,532.55	**74,103.00**	0.397	29,418.89	**69,222.00**	0.397	27,481.13
Asrama Keduabelas (12)	**244,281.00**	0.397	96,979.56	**202,816.00**	0.397	80,517.95	**170,210.00**	0.397	67,573.37	**267,341.00**	0.397	106,134.38	**212,468.00**	0.397	84,349.80	**184,903.00**	0.397	73,406.49

Asrama	Julai			Ogos			September			Oktober			November			Disember		
	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)
Asrama Pertama (1)	**60,539.00**	0.397	24,033.98	**44,217.00**	0.397	17,554.15	**54,196.00**	0.397	21,515.81	**53,555.00**	0.397	21,261.34	**53,711.00**	0.397	21,323.27	**55,925.00**	0.397	22,202.23
Asrama Kedua (2)	**81,418.00**	0.397	32,322.95	**57,833.00**	0.397	22,959.70	**74,421.00**	0.397	29,545.14	**65,904.00**	0.397	26,163.89	**60,175.00**	0.397	23,889.48	**69,181.00**	0.397	27,464.86
Asrama Ketiga (3)	**67,586.00**	0.397	26,831.64	**60,422.00**	0.397	23,987.53	**71,681.00**	0.397	28,457.36	**71,867.00**	0.397	28,531.20	**62,600.00**	0.397	24,852.20	**68,632.00**	0.397	27,246.90
Asrama Keempat (4)	**55,646.00**	0.397	22,091.46	**55,311.00**	0.397	21,958.47	**24,703.00**	0.397	9,807.09	**47,228.00**	0.397	18,749.52	**54,522.00**	0.397	21,645.23	**37,785.00**	0.397	15,000.65
Asrama Kelima (5)	**48,498.00**	0.397	19,253.71	**49,772.00**	0.397	19,759.48	**49,800.00**	0.397	19,770.60	**46,136.00**	0.397	18,315.99	**22,813.00**	0.397	9,056.76	**51,122.00**	0.397	20,295.43
Asrama Keenam (6)	**88,918.00**	0.397	35,300.45	**62,332.00**	0.397	24,745.80	**83,145.00**	0.397	33,008.57	**76,308.00**	0.397	30,294.28	**79,831.00**	0.397	31,692.91	**84,016.00**	0.397	33,354.35
Asrama Ketujuh (7)	**61,498.00**	0.397	24,414.71	**64,542.00**	0.397	25,623.17	**27,865.00**	0.397	11,062.41	**89,753.00**	0.397	35,631.94	**49,862.00**	0.397	19,795.21	**40,653.00**	0.397	16,139.24
Asrama Kelapan (8)	**80,255.00**	0.397	31,861.24	**67,632.00**	0.397	26,849.90	**89,704.00**	0.397	35,612.49	**85,467.00**	0.397	33,930.40	**73,565.00**	0.397	29,205.31	**75,737.00**	0.397	30,067.59
Asrama Kesepuluh (10)	**45,735.00**	0.397	18,156.80	**38,816.00**	0.397	15,409.95	**52,246.00**	0.397	20,741.66	**46,689.00**	0.397	18,535.53	**48,230.00**	0.397	19,147.31	**48,998.00**	0.397	19,452.21
Asrama Kesebelas (11)	**70,465.00**	0.397	27,974.61	**95,786.00**	0.397	38,027.04	**35,121.00**	0.397	13,943.04	**106,507.00**	0.397	42,283.28	**62,261.00**	0.397	24,717.62	**53,422.00**	0.397	21,208.53
Asrama Keduabelas (12)	**236,576.00**	0.397	93,920.67	**220,266.00**	0.397	87,445.60	**92,449.00**	0.397	36,702.25	**316,057.00**	0.397	125,474.63	**141,925.00**	0.397	56,344.23	**191,341.00**	0.397	75,962.38

Appendix I: Electricity Consumption in UM main campus Residential College 2011

PENGGUNAAN ELEKTRIK ASRAMA UM 2011

Asrama	Januari			Februari			Mac			April			Mei			Jun		
	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)
Asrama Pertama (1)	47,049.00	0.397	18,678.45	61,490.00	0.397	24,411.53	52,561.00	0.397	20,866.72	57,990.00	0.397	23,022.03	54,490.00	0.397	21,632.53	31,470.00	0.430	13,532.10
Asrama Kedua (2)	60,135.00	0.397	23,873.60	75,339.00	0.397	29,909.58	62,247.00	0.397	24,712.06	69,925.00	0.397	27,760.23	68,675.00	0.397	27,263.98	51,048.00	0.430	21,950.64
Asrama Ketiga (3)	61,852.00	0.397	24,555.24	78,081.00	0.397	30,998.16	70,958.00	0.397	28,170.33	80,688.00	0.397	32,033.14	75,151.00	0.397	29,834.95	47,279.00	0.430	20,329.97
Asrama Keempat (4)	55,619.00	0.397	22,080.74	39,669.00	0.397	15,748.59	49,241.00	0.397	19,548.68	53,975.00	0.397	21,428.08	47,026.00	0.397	18,669.32	29,556.00	0.430	12,709.08
Asrama Kelima (5)	75,180.00	0.397	29,846.46	53,158.00	0.397	21,103.73	62,313.00	0.397	24,738.26	79,494.00	0.397	31,559.12	53,461.00	0.397	21,224.02	49,603.00	0.430	21,329.29
Asrama Keenam (6)	65,476.00	0.397	25,993.97	81,565.00	0.397	32,381.31	71,384.00	0.397	28,339.45	74,238.00	0.397	29,472.49	70,379.00	0.397	27,940.46	71,180.00	0.430	30,607.40
Asrama Ketujuh (7)	66,930.00	0.397	26,571.21	48,614.00	0.397	19,299.76	58,715.00	0.397	23,309.86	66,200.00	0.397	26,281.40	53,044.00	0.397	21,058.47	29,459.00	0.430	12,667.37
Asrama Kelapan (8)	73,349.00	0.397	29,119.55	89,028.00	0.397	35,344.12	82,294.00	0.397	32,670.72	89,903.00	0.397	35,691.49	76,105.00	0.397	30,213.69	44,011.00	0.430	18,924.73
Asrama Kesepuluh (10)	42,554.00	0.397	16,893.94	59,648.00	0.397	23,680.26	52,446.00	0.397	20,821.06	58,198.00	0.397	23,104.61	57,232.00	0.397	22,721.10	48,226.00	0.430	20,737.18
Asrama Kesebelas (11)	80,976.00	0.397	32,147.47	58,521.00	0.397	23,232.84	65,973.00	0.397	26,191.28	83,233.00	0.397	33,043.50	60,666.00	0.397	24,084.40	51,832.00	0.430	22,287.76
Asrama Keduabelas (12)	267,163.00	0.397	106,063.71	166,973.00	0.397	66,288.28	201,370.00	0.397	79,943.89	219,971.00	0.397	87,328.49	139,879.00	0.397	55,531.96	165,044.00	0.430	70,968.92

Asrama	Julai			Ogos			September			Oktober			November			Disember		
	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)	Penggunaan (KWh)	Kadar	Amaun (RM)
Asrama Pertama (1)	24,361.00	0.430	10,475.23	20,460.00	0.430	8,797.80	46,373.00	0.430	19,940.39	54,861.00	0.430	23,590.23	55,843.00	0.430	24,012.49	54,356.00	0.430	23,373.08
Asrama Kedua (2)	46,332.00	0.430	19,922.76	34,469.00	0.430	14,821.67	60,817.00	0.430	26,151.31	63,319.00	0.430	27,227.17	62,440.00	0.430	26,849.20	59,166.00	0.430	25,441.38
Asrama Ketiga (3)	36,023.00	0.430	15,489.89	23,408.00	0.430	10,065.44	56,767.00	0.430	24,409.81	53,242.00	0.430	22,894.06	59,229.00	0.430	25,468.47	55,331.00	0.430	23,792.33
Asrama Keempat (4)	34,948.00	0.430	15,027.64	28,901.00	0.430	12,427.43	39,804.00	0.430	17,115.72	60,754.00	0.430	26,124.22	48,447.00	0.430	20,832.21	49,046.00	0.430	21,089.78
Asrama Kelima (5)	38,578.00	0.430	16,588.54	31,588.00	0.430	13,582.84	52,485.00	0.430	22,568.55	56,390.00	0.430	24,247.70	52,411.00	0.430	22,536.73	67,918.00	0.430	29,204.74
Asrama Keenam (6)	64,333.00	0.430	27,663.19	72,859.00	0.430	31,329.37	73,013.00	0.430	31,395.59	78,466.00	0.430	33,740.38	77,730.00	0.430	33,423.90	75,443.00	0.430	32,440.49
Asrama Ketujuh (7)	33,877.00	0.430	14,567.11	29,670.00	0.430	12,758.10	46,007.00	0.430	19,783.01	69,138.00	0.430	29,729.34	52,740.00	0.430	22,678.20	59,041.00	0.430	25,387.63
Asrama Kelapan (8)	36,395.00	0.430	15,649.85	27,271.00	0.430	11,726.53	69,059.00	0.430	29,695.37	65,146.00	0.430	28,012.78	84,715.00	0.430	36,427.45	80,692.00	0.430	34,697.56
Asrama Kesepuluh (10)	44,064.00	0.430	18,947.52	33,583.00	0.430	14,440.69	53,461.00	0.430	22,988.23	45,116.00	0.430	19,399.88	52,276.00	0.430	22,478.68	45,513.00	0.430	19,570.59
Asrama Kesebelas (11)	59,819.00	0.430	25,722.17	49,243.00	0.430	21,174.49	59,991.00	0.430	25,796.13	79,715.00	0.430	34,277.45	68,535.00	0.430	29,470.05	73,370.00	0.430	31,549.10
Asrama Keduabelas (12)	187,862.00	0.430	80,780.66	161,359.00	0.430	69,384.37	197,933.00	0.430	85,111.19	201,840.00	0.430	86,791.20	178,115.00	0.430	76,589.45	236,959.00	0.430	101,892.37

Appendix J: Buildings in UM and their respective floor area

BIL. BLOK	BANGUNAN DENGAN CENTRAL AIR-COND	KOD BLOK	BANGUNAN	TINGKAT	TURUTAN BIL BLOK	TINGKAT
		Pentadbiran				
1		A01	Dewan Tunku Canselor	113,325.27		113,325.27
1	1	A01	ET	30,000.00	1	30,000.00
2		A02	Bangunan Canseleri	53,090.53	2	
3	2	A03	Bendahari/Pentadbiran Baru	21,471.03	3	21,471.03
4		A05	Mural Ibrahim Hussein	2266.88	4	
5		A06	Stor Sukan Kayak	538.97	5	
6		A07	Perdanasiswa A,B	24,215.82	6 & 7	
7		A08	Perdanasiswa C	20,286.94	8	
8		A09	Perdanasiswa D,E	55,554.46	9 & 10	
9		A10	Perdanasiswa F	44,008.26	11	
10		A11	Perdanasiswa G	10,290.77	12	
11		A12	Cooling Tower 1			
12	3	A13	Perpustakaan Utama	194,734.05	13	194,734.05
12	4	A14	Dewan Peperiksaan	128,909.91	14	128,909.91
		A15	Cooling Tower 2			
		A16	RU Kafeteria	19,005.04	15	
		A17	RU Hotel	16,259.47	16	
		A18	Cooling Tower 3			
		A19	Cooling Tower 4			
	5	A20	Bangunan Canseleri baru	204,440.00	17	204,440.00
		A04	kantin Canseleri	4,453.89	18	
		Pusat Asasi Sains, ISB Genetik & Ambang Asuhan Jepun				
		B01	Pejabat Dekan	3,395.15	19	
	6	B02	Dewan Kuliah 1,2 & 3	3,443.66	20	3,443.66
		B04	Pekan Asasi Sains	975.33	21	
		B07	Blok Makmal Biologi Baru	28213.68	22	
		B10	Dewan Kuliah A & B	22060.71	23	
		B11	Makmal Fizik & Makmal Kimia 4	15670.86	24	
		B12	Bengkel	13139.12	25	
		B18	Makmal Fizik 3	4,312.14	26	
		B19	Makmal Kimia 5 & Surau	4,626.42	27	
		B23	DK Utama	9,606.92	28	
		B24	Bilik Tutorial 1,2,3	2,029.77	29	
		B25	Bilik Tutorial 4,5,6	2,792.96	30	
		B26	Bilik Tutorial 7,8,9	2,793.20	31	
		B27	Bilik Tutorial 10,11,12	2,792.96	32	
		B30	Bilik Tutorial 13,14,15	1,935.12	33	
		B36	Bilik Komputer	8,971.58	34	
		B37	Blok Pensyarah	19,525.50	35	

Prepared by

BAHAGIAN PENGURUSAN HARTA
JABATAN PEMBANGUNAN & PENYELENGGARAAN
HARTA BENDA
UNIVERSITI MALAYA
NO. TEL : 03-79676830 NO. FAX : 03-79676848

7	B16	Bangunan Baru PASUM	237,993.00	36	237,993.00
	B17	Kantin PASUM	5287.46	37	
	B3	Genetik & Biologi Sel (Wing B)	14366.45	38	
	B5	Genetik & Biologi Sel (Wing D)	12735.79	39	
	B6	Genetik & Biologi Sel (Wing C)	17184.01	40	
	B8	Asasi Sains Biokimia	16508.93	41	
	B9	Makmal Pendidikan / Penerbit	12660.03	42	
	B45	Rumah Elektrik	530.55	43	
	B20	Cluster 1-Bilik Tutor A 5,6,7	2,924.41	44	
	B21	Cluster 2-Bilik Tutor A 1,2,3,4	2,876.75	45	
	B22	Bilik Mesyuarat (Cluster 4)	2,200.38	46	
	B28	Pejabat (Cluster 3)	2,877.94	47	
	B29	Cluster 5-Surau	2,684.57	48	
	B31	Cluster 6-Bilik Pensyarah 4 & 5	4,294.78	49	
	B32	Cluster 8-Makmal Bahasa 1,2 & Blk.Audio Visual	3,897.01	50	
	B33	Cluster 7-Bilik Tutor A 8,9,10	5,490.86	51	
8	B34	Dewan Kuliah A1	3,506.90	52	3,506.90
9	B35	Dewan Kuliah A2	1,708.87	53	1,708.87
	B38	Cluster 9-Makmal Fizik & Kimia	11,334.05	54	
	B40	Tandas 1	569.68	55	
	B41	Tandas 3	569.68	56	
	B42	Tandas 2	831.19	57	
	B43	Wakaf (Pondok Rehat)	1,049.65	58	
	B44	Rumah Gas	271.36	59	
	B39	Sub-Stesen-TNB (33 Kv)	20629.26	60	
	Fakulti Undang-Undang				
	C01	Bangunan Sultan Azlan Shah	68235.41	61	
10	C02	Perpustakaan Undang-Undang	67630.96	62	67630.96
	C03	Kafeteria Undang-Undang	2,438.04	63	
	C04	TNB	610.22	64	
11	C05	Moot Court	21025.4	65	21025.4
	Kolej Kediaman Pertama				
	D 01	Blok A	29334.46	66	
	D 02	Blok B	25260.77	67	
	D 03	Blok C	14888.35	68	
	D 04	Rumah Rehat Pekerja	937.75	69	
	D 05	Bengkel	1,388.43	70	
	D 06	Setor	558.00	71	
	D 07	Tempat Buang Sampah	111.77	72	
	D 08	Blok D	28816.59	73	
	D 09	Blok E	28911.28	74	
	D 10	Kafeteria	1,587.09	75	
	D 19	Rumah Pengetua	4427.35	76	
	D 21	Pusat Sukan- Gimnasium	6,321.08	77	
	D 11	Pusat Sukan- Gimnasium	4,892.66	78	

	D 12	Blok E	27208.53	79	
	D 13	Blok Pentadbiran	14158.07	80	
	D 14	Blok D	20431.8	81	
	D 15	Blok A	13884.3	82	
	D 16	Dapur dan Dewan Makan	14141.51	83	
	D 17	Blok B	30392.53	84	
	D 18	Blok C	20343.99	85	
	D 20	Rumah Pengetua	4074.85	86	
	D 22	Rumah Rehat Kakitangan	1,946.87	87	
	D 23	Setor Sukan Kolej 2	386.60	88	
	D 24	Bilik Semaian Minda	460.37	89	
	Fakulti Pergigian				
12	D 25	Fak Pergigian - Balai Ungku Aziz	95941.41	90	95941.41
	Dewan Peperiksaan				
13	E 0-1	Dewan Peperiksaan	191,862.64	91	191,862.64
	Fakulti Perubatan				
14	F 01 BLOK A	Pejabat Dekan,	16695.8	92	16695.8
	F 02 BLOK B	Mak. Bioteknologi Perubatan Makmal Pelbagai Ilmu 1	30936.07	93	
	F 03 BLOK C	Anatomi, Fisiologi, Fisiologi,	30936.07	94	
	F 04 BLOK D	Anatomi, Makmal Pelbagai Ilmu 1 Makmal Pelbagai Ilmu 1 Makmal Pelbagai Ilmu 1 Mak.Kemahiran Klinikal,	34117.01	95	
	F 05 BLOK E	Anatomi, Anatomi, Makmal Pelbagai Ilmu 1	37129.03	96	
	F 06 BLOK F	Anestesiologi,Perubatan Molekul,Farmakologi, Farmakologi,	24193.44	97	
	F 07 BLOK G	Perubatan Molekul, Farmakologi,	24508.4	98	
15	F 08 BLOK H	Perpustakaan. Illustrasi Perubatan Makmal Pelbagai Ilmu 2	31228.18	99	31228.18
	F 09 BLOK I	Pejabat Dekan,Unit Mic Elekt, Bhg Lep Ijazah Unit Pembg Pend & Peny. Per, Surgeri Orthopedik, Pediatriks, Perubatan Kemasyarakatan & Pencegahan.	36355.38	100	
	F 10 BLOK J	Pejabat Dekan, Bhg. Lepasan Ijazah Perubatan Kemasyarakatan & Pencegahan. Perubatan Kemasyarakatan & Pencegahan.	36394.62	101	
16	F 11	Dewan Kuliah	28673.7	102	28673.7

	BLOK K	Dewan Kuliah, Perpustakaan Dewan Kuliah Dewan Kuliah			
	F 12 BLOK L	Unit Haiwan Makmal Jabatan Fisiologi Unit Haiwan Makmal Unit Haiwan Makmal Unit Haiwan Makmal	11822.95	103	
17	F 13 BLOK M	Bengkel Grafik & Muzium Pusat Perpustakaan. Muzium Pusat, Illustrasi Perubatan Makmal Pelbagai Ilmu 2	37880.93	104	37880.93
18	F 14 BLOK N	Perubatan Forensik (Mortuari) Patologi, Anestesiologi,Micr. Perubatan, Unit Penyakit Berjangkit Parasitologi,	47834.84	105	47834.84
	F 15 BLOK O	Patologi, Anestesiologi, Microbiologi Perubatan Parasitologi,	36394.62	106	
	F 16 BLOK P	Surgeri Orthopedik, Surgeri, Anestesiologi, Surgeri Orthopedik Oftalmologi, Otorhinolaringologi, Jab. Perubatan, Perubatan Psikologi,	24626.3	107	
	F 17 BLOK Q	Pejabat Dekan, Pejabat Dekan,	9645.16	108	
	F 18 BLOK R	Pejabat Dekan, Farmasi Pejabat Dekan,Per. Pemulihan, Perubatan Molekul Pejabat Dekan,Per. Pemulihan, Unit Perub. Sukan Perubatan Molekul. Farmasi,	84771.75	109	
	F 19	Pusat Haiwan Makmal	13,662.99	110	
	F ?	MD 2	44,282.19	111	
19	F ?	BSL Lab	4,196.00	112	4,196.00
	Fak Pergigian				
	F 20	Fak Pergigian - Blok A	57934.25	113	
	F 21	Fak Pergigian - Blok B	20465.53	114	
	F 22	Fak Pergigian - Blok C	157,120.21	115	
20	F 23	Fak Pergigian - Blok D	44695.29	116	44695.29
	Kolej Kediaman Keenam				
	F 24	Ibnu Sina Blok A	37755.99	117	
	F 25	Blok B	29,268.95	118	
	F 26	Blok CDEF	28,735.28	119-122	
	F 27	Blok G	21,132.87	123	
	F 28	Blok H	21,432.23	124	
	F 29	Dewan Makan	34,126.00	125	
	F 30	Rumah Pengetua	4,006.88	126	

	F 31	Kafeteria	2,747.98	127	
	Fakulti Kejuruteraan				
	G 01	Jab.Kej. Bioperubatan	18,909.72	128	
	G 02	Dewan Kuliah 1	2,193.81	129	
	G 04	Blok Struktur Lanjutan	35,454.35	130	
	G 05	Makmal Kejuruteraan Awam	28,178.95	131	
	G 06	Blok Mak.Kej. Elektrik	14,714.32	132	
	G 07	Blok Penyelidikan	16,750.55	133	
	G 08	Jab.Kej. R/Btk Dan Pembuatan	19,210.40	134	
	G 09	Kantin	2,138.63	135	
	G 10	Makmal Kej.R/Btk Dan Pembuatan	12,974.87	136	
	G 11A	Menara Kejuruteraan - Blk Makmal	114,133.25	137	
	G 11B	Menara Kejuruteraan - Blk Pentadbiran	96,855.76	138	
	G 12	Blok Hidraulik	55,275.98	139	
	G 13	Blok Kej. Kesihatan Awam	11,520.84	140	
	G 14	Blok Kuliah	66,042.73	141	
	G 15	Dewan Kuliah 2 & 3	24,677.79	142	
	G 16	Jab.Kejuruteraan Kimia	54,909.19	143	
	G 17	Blok Tambahan Jab.Kej.Kimia	15,365.55	144	
	G 18	Blok Kajilogam	12,447.81	145	
	G 19	Blok M&E	34,337.02	146	
	G 20	Blok Letak Kereta	65,620.03	147	
	G 23	Setor	595.86	148	
	Fakulti Alam Bina				
	G 21	Blok Kuliah - Alam Bina	101,131.79	149	
	G 22	Blok Ukur	85497.28	150	
21	G ?	Mercu Alam Bina	221,860.44	151	221,860.44
	Fakulti Perniagaan & Perakaunan				
	H 01	Blok Pentadbiran & Pensyarah	28,548.30	152	
22	H 03	Dewan Kuliah	44,184.39	153	44,184.39
	H 04	Blok Seminar	18,021.29	154	
	Perpustakaan Za'ba				
23	H 02	Perpustakaan Zaa'ba	75,078.33	155	75,078.33
	Kebudayaan				
24	H 05	Muzium Seni Asia	19,095.71	156	19,095.71
	H 07	Blok Orkestra - Pusat Kebudayaan	3,227.65	157	
	Fak. Ekonomi & Pentadbiran				
	H 08	Blok Makmal Komputer	17,707.72	158	
	H 09	Komplek Blok Seminar	24,142.10	159	
	H 10	Blok Pentadbiran	42,053.39	160	
25	H 11	Dewan Kuliah	76,573.54	161	76,573.54
	H 12	Bangunan Pascasiswazah	62,933.31	162	
	Fak. Sastera & Sains Sosial				
	I 01	Siswarama	54,261.19	163	
	I 02	Sejarah	17,834.09	164	
26	I 03	Dewan Kuliah F	12,677.66	165	12,677.66

	I 04	3 Dimensi	41,940.97	166	
	I 05	Blok H	33,778.97	167	
27	I 06	DK D & E	8,502.33	168-169	8,502.33
28	I 07	DK A,B,C	10,828.62	170-172	10,828.62
	I 08	Bangunan Tambahan	89,491.35	173	
	I 09	Blok A - Fak Pendidikan	17,175.55	174	
	I 10	Blok B	15,668.52	175	
	I 11	Blok C	18,333.62	176	
	I 12	Blok E	20,883.59	177	
	I 13	Makmal MD	41,416.75	178	
	I 14	Blok D	10,643.87	179	
29	I 15	Dewan Kuliah	17,597.49	180	17,597.49
	I 16	SKET	19,609.54	181	
	I 17	Pentadbiran	29,048.71	182	
	I 18	Kantin	2,749.47	183	
	Fakulti Sains				
	J 01	Dekan / Pentadbiran Dan Sains Teknologi	13,056.36	184	
30	J 02	Dewan Kuliah 2	7,477.00	185	7,477.00
	J 03	Dewan Kuliah 4	10,186.02	186	
31	J 04	Dewan Kuliah 3	2,934.65	187	2,934.65
32	J 05	Kimia Baru	76,046.12	188	76,046.12
	J 06	Kimia Lama	31,788.45	189	
	J 07	Blok MUCED	18,667.81	190	
	J 08	Kimia Tambahan & Teknologi	70,540.07	191	
	J 09	Dewan Kuliah 1	3,359.54	192	
	J 11	Botani & Zoologi	48,864.13	193	
	J 12	Makmal Sains Baru	80,494.39	194	
	J 13	Sains Botani (Zoologi)	35,531.39	195	
	J 14	Blok F (ISB)	9,426.56	196	
	J 15	Blok Matematik (ISM)	38,163.26	197	
	J 16	Jabatan Bionformatik	36,479.11	198	
	J 17	Jabatan Fizik Blok C	26,343.70	199	
	J 18	Jabatan Fizik Blok B	22,024.38	200	
	J 19	Jabatan Fizik Blok A	34,333.76	201	
	J 20	AMCAL	8,482.49	202	
	J 21	Geologi Baru	25,650.79	203	
	J 22	Geologi Lama	36,063.49	204	
33	J 23	Kompleks Dewan Kuliah	68,693.33	205	68,693.33
	J 30	Bunker	3,038.61	206	
34	J ?	Bangunan Baru Sains Kimia	228,542.40	207	228,542.40
	J ?	Kantin	4,674.66	208	
	J 32	Tandas	1098.38	209	
	J 10	Pusat Teknologi Maklumat	33,575.49	210	
	J 24	Bangunan Pusat Bahasa	53,231.05	211	
35	J 25	DK Angsana & Beringin	32,351.09	212	32,351.09

J 26	Pusat Bahasa (makmal)	27,788.69	213	
J 27	Kantin	1,794.96	214	
J 28	Tangki Air			
Kolej Kediaman KeEmpat				
K 01	Blok A	33,849.74	215	
K 02	Blok B	29,031.89	216	
K 03	Blok C	23,228.86	217	
K 04	Kedai	1,402.15	218	
K 05	Blok D	28,565.92	219	
K 06	Rumah Pengetua	4,096.37	220	
K 21	Gerai Makan & Dobi	2,835.49	221	
Kolej Kediaman Ketujuh				
K 07	Blok A	28,578.22	222	
K 08	Blok B	18,941.49	223	
K 09	Blok C	16,921.68	224	
K 10	Blok D	18,619.48	225	
K 11	Pentadbiran & Dewan	19,429.43	226	
K 12	Rumah Pengetua	3,660.32	227	
K 24	Gerai	1,404.50	228	
K 26	Seri Jati	1,463.66	229	
Kolej Kediaman Ketiga				
K 13	Blok E	27,141.47	230	
K 14	Blok C	29,660.87	231	
K 15	Dewan Makan	17,870.31	232	
K 16	Persidangan	7,588.85	233	
K 17	Surau & Bilik Mesyuarat	3,211.66	234	
K 18	Blok B	12,466.14	235	
K 19	Blok A	17,823.99	236	
K 20	Gerai	1,537.64	237	
K 21	Rumah Pengetua	2,952.08	238	
K 23	Tempat Buang Sampah	608.97	239	
	Akademi Pengajian Melayu			
L 01	Blok Utama	123,575.11	240	
L 02	Tangki Air			
L 03	Tangki Air			
	Kolej Kediaman Kesepuluh			
M 01	Pentadbiran & Dewan Makan	40,040.19	241	
M 02	Rumah Pengetua	4,989.17	242	
M 03	Blok Kenyalang 1	25,089.96	243	
M 04	Blok Santubong 2	23,934.82	244	
M 05	Blok Kenyalang 2	25,068.79	245	
M 06	Blok Santubong 1	23,934.81	246	
M 18	Gerai	3,354.33	247	
M 19	Rumah Kakitangan	818.19	248	
	Kolej Kediaman Kelapan			
M 07	Blok A	12,287.13	249	

	M 08	Blok B	15,514.07	250	
	M 09	Blok C	11,236.09	251	
	M 10	Blok D	12,206.39	252	
	M 11	Blok E	15,293.81	253	
	M 12	Blok F	14,896.84	254	
36	M 13	Pentadbiran & Dewan Makan	37,334.05	255	37,334.05
	M 14	Rumah Pengetua	3,247.89	256	
	M 17	Gerai Makan	2,872.95	257	
9	M 21	Surau	3,265.43	258	
	Fakulti Sains Komputer Dan Teknologi Maklumat				
	M15	Bangunan Annex	72,801.26	259	
	M16	Pentadbiran	42,550.57	260	
	M23	Kantin	3807.10	261	
	Kompleks Palapes				
	N 01	Blok Pentadbiran	7,845.17	262	
	N 02	Setor Senjata	1,153.78	263	
	N 03	Bilik Seminar	4,266.94	264	
	N 04	Rumah Elektrik	432.30	265	
	N 05	Pondok Pengawal	306.23	266	
	N 06	Dewan Serbaguna	4,942.67	267	
	N 07	Blok Pentadbiran Baru	2,352.94	268	
	N 08	Blok Plantun Kenderaan	500.52	269	
	N 09	Wakaf Surau	814.71	270	
	Akademi pengajian Islam				
37 - 40	O 01	Blok A,B,C,D	303,795.74	271-274	303,795.74
	O 02	Surau	3,221.13	275	
		Pusat Sukan			
	O 02	Kompleks Squash Blok B	12,090.77	276	
	O 03	Kompleks Squash Blok A	5,697.85	277	
		Institut Sains Biologi			
41	4	Herbarium	31,839.19	278	31,839.19
	P 01	Pentadbiran & Gimnasium	61,981.89	279	
	P 02	Kompleks Kolam Renang	33,843.70	280	
42	P 10	Bangunan Baru Pusat Sukan	23148.99	281	23148.99
	P ?	Stadium Sains Sukan (termasuk padang)	357,081.36	282	
	Kolej Kesebelas				
	P 04	Blok D & C	128,351.90	283-284	
	P 03	Blok A & B	120,889.53	285-286	
	P 05	Rumah Pengetua	3,179.24	287	
	P 06	Blok Pentadbiran & Dewan Makan	19,943.03	288	
	P 08	Kedai Makan dan Kedai Runcit	6,823.09	289	
	Institut Sains Biologi				
	P 07	Bangunan Pusat Aktiviti Rimba Ilmu	2,360.66	290	
	JPPHB				
43	P 09	Setor Baru JPPHB	Tingkat Bawah	291	Tingkat Bawah
	Kolej Kelima				

	Q 01	Blok Azalia	41,920.42	292	
	Q 02	Blok Bougainvilla	42,310.13	293	
	Q 03	Blok Camelia	42,408.68	294	
	Q 04	Blok Dahlia	40,967.58	295	
	Q 05	Blok Eplisia	42,358.66	296	
	Q 06	Blok F (Pentadbiran)	24,040.51	297	
	Q 07	Rumah Pengetua	4,281.24	298	
	Q 08	Gerai	3,306.37	299	
	Q 09	Astaka	2,637.15	300	
	Q 10	Surau	3,839.30	301	
	Q 11	RR & Kedai Jahit	3,486.42	302	
	Q 24	Pondok Dobi	281.39	303	
	Q 25	Setor Kain	377.11	304	
	Q 26	Setor Peralatan	1,127.80	305	
		JPPHB			
	Q 12	Pentadbiran JPPHB - Bangunan Utama	47,285.25	306	
	Q 13	Setor Barang	2,870.92	307	
	Q 14	Bengkel	2,576.43	308	
	Q 15	Blok Kantin	3,079.02	309	
	Q 16	Pejabat ladang ISB	2,755.66	310	
	Q 17	Bilik rehat	206.88	311	
	Q 18	Tandas	189.67	312	
	Q 19	Setor A	265.52	313	
	Q 20	Setor B	505.30	314	
	Q 21	Unit Ayam Daging	1,225.91	315	
	Q 22	Unit Ayam Telur	1,225.91	316	
		INSTITUT ASIA EROPAH			
44	R 01	Institut Asia Eropah	39,165.54	317	39,165.54
		INSTITUT PENGAJIAN SISWAZAH			
	R 03	Blok A	62,331.26	318	
	R 04	Blok B	58,573.71	319	
	R 05	Blok C	62,532.70	320	
	R 06	Blok D	61,632.01	321	
	R 11	Kantin IPS	2,408.26	322	
	R 02	Blok E	21,873.26	323	21,873.26
45	R ?	IPPP	164,929.28	324	164,929.28
		KOLEJ KEDIAMAN KE DUABELAS			
	R07	Blok C & D	466,582.74	325-326	
	R08	Blok A & B	465,021.01	327-328	
46	R09	Dewan Makan & Pentadbiran	36,129.24	329	36,129.24
	R10	Kolej 12 - Rumah Pengetua	2,316.90	330	
	PERUMAHAN KAKITANGAN LRG U				
	Jenis B				
	S 01	No. 01 Lorong Universiti	2,291.86	331	
	S 02	No. 03 Lorong Universiti	2,291.86	332	
	S 03	No. 05 Lorong Universiti	2,291.86	333	

S 04	No. 31 Lorong Universiti	2,291.86	334	
S 05	No. 33 Lorong Universiti	2,291.86	335	
S 06	No. 27 Lorong Universiti	2,291.86	336	
S 07	No. 29 Lorong Universiti	2,291.86	337	
S 08	No. 34 Lorong Universiti	2,291.86	338	
S 09	No. 32 Lorong Universiti	2,291.86	339	
S 10	No. 30 Lorong Universiti	2,291.86	340	
S 11	No. 28 Lorong Universiti	2,291.86	341	
S 12	No. 26 Lorong Universiti	2,291.86	342	
S 13	No. 24 Lorong Universiti	2,291.86	343	
S 14	No. 22 Lorong Universiti	2,291.86	344	
S 15	NO 20 Lorong Universiti	2,291.86	345	
S 16	No. 18 Lorong Universiti	2,291.86	346	
S 17	No. 16 Lorong Universiti	2,291.86	347	
Jenis C				
S 18	No. 14 Lorong Universiti	2,352.49	348	
S 19	No. 12 Lorong Universiti	2,357.33	349	
Jenis B				
S 20	No. 10 Lorong Universiti	2,291.86	350	
S 21	No. 08 Lorong Universiti	2,291.86	351	
S 22	No. 06 Lorong Universiti	2,291.86	352	
S 23	No. 04 Lorong Universiti	2,291.86	353	
S 24	No. 02 Lorong Universiti	2,291.86	354	
S 25	No. 07 Lorong Universiti	2,291.86	355	
S 26	No. 09 Lorong Universiti	2,291.86	356	
S 27	No. 11 Lorong Universiti	2,291.86	357	
Jenis A				
S28	NO 13 Lorong Universiti	3,917.69	358	
S29	NO 15 Lorong Universiti	3,917.70	359	
S30	NO 17 Lorong Universiti	3,917.70	360	
S31	NO 19 Lorong Universiti	3,917.69	361	
S32	NO 21 Lorong Universiti	3,917.70	362	
S33	NO 23 Jln Lorong Universiti	3,917.70	363	
	JENIS B			
S34	No. 25 Lorong Universiti	2,291.86	364	
35	UMSC			
36	Guard House PJ gate			
KOLEJ KEDIAMAN KE 9				
T01	Klj 9-Sri Worawari	22,763.61	365	
T02	Klj 9-Sri Kemboja	21,068.03	366	
T03	Klj 9-Sri Bakawali	19,876.37	367	
T04	Klj 9-Pentadbiran & Dewan Makan	52,264.97	368	
T05	Klj 9-Sri Cempaka	25,189.05	369	
T06	Klj 9-Sri Melor	22,078.26	370	
T07	Klj 9-Sri Seroja	21,908.64	371	

T08	Klj 9-Rumah Pengetua	3,871.41	372	
T09	Klj 9-Kedai Makan	2,612.62	373	
KEDIAMAN KAKITANGAN APARTMENT JEPUN				
T70	Apartment Jepun	37,065.35	374	
	JENIS A1			
T10	01 Lorong 16 / 10C	3,375.36	375	
T12	03 Lorong 16 / 10C	3,375.36	376	
T19	03 Lorong 16 / 4A	3,375.36	377	
T20	01 Lorong 16 / 4A	3,375.36	378	
T21	10 Jalan 16 / 4	3,375.36	379	
T25	09 Jalan 16 / 8	3,375.36	380	
T27	12 Jalan 16 / 4	3,375.36	381	
T29	14 Jalan 16 / 4	3,375.36	382	
T30	16 Jalan 16 / 4	3,375.36	383	
T32	17 Jalan 16 / 4	3,375.36	384	
T33	09 Jalan 16 / 10	2,722.41	385	
T34	07 Jalan 16 / 10	3,375.36	386	
T35	05 Jalan 16 / 10	3,375.36	387	
T36	03 Jalan 16 / 10	3,375.36	388	
T44	01 Lorong 16 / 10A	3,375.36	389	
T45	06 Lorong 16 / 10A	3,375.36	390	
T46	04 Lorong 16 / 10A	3,375.36	391	
T56	39 Jalan 16 / 2	3,375.36	392	
T58	55 Jalan 16 / 2	3,375.34	393	
T59	80 Jalan 16 / 2	3,375.34	394	
T60	53 Jalan 16 / 2	3,375.34	395	
T61	78 Jalan 16 / 2	3,375.34	396	
T63	76 Jalan 16 / 2	3,375.34	397	
T64	74 Jalan 16 / 2	3,375.34	398	
T68	43 Jalan 16 / 2	3,375.36	399	
T69	41 Jalan 16 / 2	3,375.36	400	
	JENIS A2			
T24	07 Jalan 16 / 8	3,375.36	401	
T14	05 Lorong 16 / 10C	3,375.36	402	
T16	07 Lorong 16 / 10C	3,375.36	403	
T18	09 Lorong 16 / 10C	3,375.36	404	
T26	13 Jalan 16 / 4	3,375.36	405	
T28	15 Jalan 16 / 4	3,375.36	406	
T31	18 Jalan 16 / 4	3,375.36	407	
T37	01 Jalan 16 / 10	3,375.36	408	
T41	04 Jalan 16 / 10B	3,375.36	409	
T42	02 Jalan 16 / 10B	3,375.36	410	
T43	03 Lorong 16 / 10A	3,375.36	411	
T47	02 Lorong 16 / 10A	3,375.36	412	
T48	10 Lorong 16 / 10	3,375.36	413	
T49	08 Jalan 16 / 10	3,375.36	414	

T50	06 Jalan 16 / 10	3,375.36	415	
T51	04 Jalan 16 / 10	3,375.36	416	
T55	37 Jalan 16 / 2	3,374.62	417	
T62	51 Jalan 16 / 2	3,375.62	418	
T65	49 Jalan 16 / 2	3,375.36	419	
T67	45 Jalan 16 / 2	3,374.62	420	
	JENIS B1			
T66	47 Jalan 16 / 2	3,375.36	421	
	JENIS B2			
T22	11 Jalan 16 / 4	3,121.84	422	
T23	08 Jalan 16 / 8	3,121.84	423	
T38	10 Lorong 16 / 10B	3,121.84	424	
T39	08 Lorong 16 / 10B	3,121.84	425	
T40	06 Lorong 16 / 10B	3,121.84	426	
	APARTMENT			
T11	02 Lorong 16 / 10C	13,034.33	427	
T13	04 Lorong 16 / 10C	13,034.33	428	
T15	06 Lorong 16 / 10C	13,034.33	429	
T17	08 Lorong 16 / 10C	13,034.33	430	
T52	46 Jalan 16 / 2	13,034.33	431	
T53	02 Jalan 16 / 2	13,034.49	432	
T54	35 Jalan 16 / 2	13,034.49	433	
T57	82 Jalan 16 / 2	13,034.49	434	
	ASRAMA SEKSYEN 17			
T72	Blok Q	23,051.72	435	
T73	Blok R	21,294.88	436	
T74	Blok S	22,954.73	437	
T75	Blok T	22,954.67	438	
T76	Dewan Aman / Setor	**689.69**	439	
	PERUMAHAN KAKITANGAN SEKSYEN 12			
	Jenis A			
U01	No 01 Jln 12/5, Seksyen 12	2,232.98	440	
U02	No 02 Jln 12/5,Seksyen 12	2,232.94	441	
U03	No 03 Jln 12/5,Seksyen 12	2,233.01	442	
U05	No 05 Jln 12/5,Seksyen 12	2,233.04	443	
U07	No 07 Jln 12/5,Seksyen 12	2,232.99	444	
U26	No 32 Jln Universiti,Seksyen 12	2,232.99	445	
U27	No 34 Jln Universiti,Seksyen 12	2,232.94	446	
U28	No 36 Jln Universiti,Seksyen 12	2,273.95	447	
U29	No 38 Jln Universiti,Seksyen 12	2,799.18	448	
U30	No 40 Jln Universiti,Seksyen 12	2,233.20	449	
	Jenis B			
U04	No 04 Jln 12/5, Seksyen 12	1,964.36	450	
U06	No 06 Jln 12/5, Seksyen 12	1,964.37	451	
U08	No 08 Jln 12/5, Seksyen 12	1,964.29	452	
U09	No 10 Jln 12/5, Seksyen 12	1,964.42	453	

	U10	No 12 Jln 12/5, Seksyen 12	1,964.44	454	
	U11	No 14 Jln 12/5, Seksyen 12	1,964.41	455	
	U16	No 44 Jln 11/2, Seksyen 12	1,881.19	456	
	U17	No 17 Jln 12/7, Seksyen 12	1,964.52	457	
	U18	No 15 Jln 12/7, Seksyen 12	1,964.44	458	
	U19	No 13 Jln 12/7, Seksyen 12	1,964.42	459	
		Jenis C			
	U12	No 16 Jln 12/5, Seksyen 12	1,890.44	460	
	U13	No 18 Jln 12/5,Seksyen 12	1,890.44	461	
	U14	No 09 Jln 12/5,Seksyen 12	1,890.44	462	
	U15	No 11 Jln 12/5,Seksyen 12	1,890.44	463	
	U20	No 11 Jln 12/7, Seksyen 12	1,890.44	464	
	U21	No 09 Jln 12/7, Seksyen 12	1,890.44	465	
	U22	No 07 Jln 12/7, Seksyen 12	1,890.44	466	
	U23	No 05 Jln 12/7, Seksyen 12	1,890.44	467	
	U24	No 03 Jln 12/7, Seksyen 12	1,890.44	468	
	U25	No 01 Jln 12/7, Seksyen 12	1,890.44	469	
		KEDIAMAN KAKITANGAN LORONG JAMBATAN			
	V01	Jenis B-No 27, Lorong Jambatan	3,469.88	470	
	V02	No 29, Lorong Jambatan	3,231.08	471	
	V03	Jenis A-No 43, Lorong Jambatan	3,876.13	472	
	V04	No 41, Lorong Jambatan	3,876.13	473	
	V05	No 39, Lorong Jambatan	3,876.13	474	
	V06	Jenis D-No 60 & 58, Lorong Jambatan	4,165.72	475	
	V07	No 56 & 54, Lorong Jambatan	4,165.72	476	
	V08	No 52 & 50, Lorong Jambatan	4,165.72	477	
	V09	No 48 & 46, Lorong Jambatan	4,165.72	478	
	V10	No 44 & 42, Lorong Jambatan	4,165.72	479	
	V11	No 40 & 38, Lorong Jambatan	4,165.72	480	
	V12	No 36 & 34, Lorong Jambatan	4,165.72	481	
	V13	No 32 & 30, Lorong Jambatan	4,165.72	482	
	V14	No 28 & 26, Lorong Jambatan	4,165.72	483	
	V15	Jenis C - Apartmen Lorong Jambatan	29,520.26	484	
	KAMPUS KOTA				
47	KKA01	Blok A	109,349.44	485	109,349.44
48	KKA02	Blok C	241,660.14	486	241,660.14
	NILAM PURI				
	NPA01	Pejabat Keselamatan	519.49	487	
	NPA02	Dewan Johor & Perpustakaan	24,361.40	488	
	NPA03	Blok Kuliah	13,350.81	489	
	NPA04	Blok Pensyarah	8,063.62	490	
	NPA05	Rumah Tamu	2,309.19	491	
	NPA06	Rumah Kakitangan 01	2,402.64	492	
	NPA07	Rumah Kakitangan 02	2,402.48	493	
	NPA08	Rumah Kakitangan 03	2,402.48	494	
	NPA09	Rumah Kakitangan 04	2,402.48	495	

NPA10	Rumah Kakitangan 05	2,402.48	496	
NPA11	Kantin	1,704.17	497	
NPA12	Asrama Lelaki	26,474.51	498	
NPA13	Bangunan Pentadbiran	14,145.05	499	
NPA14	Koperasi & Setor	3,174.47	500	
NPA15	Asrama Perempuan	78,859.98	501	
ULU GOMBAK				
UGA01	Asrama	1,962.76	502	
UGA02	Makmal	1,745.56	503	
UGA05	Rumah Penyelidikan	489.95	504	
UGA03	Tandas A	431.50	505	
UGA04	Tandas B	448.88	506	
ASRAMA INDRA LOKA				
	Kuarters kakitangan	112,320.61	507	
HOSPITAL BANTING	Asrama jururawat			
	Asrama	16,319.06	508	
WISMA R & D		374,703.21	509	
	KELUASAN KESELURUHAN	**12,041,311.81**		**3,438,865.81**

BIL. BLOK

BLOK — BANGUNAN GUNA CENTRAL AIR-COND

Appendix K: Library Survey Questionnaire

UNIVERSITY OF MALAYA

The Leader in Research & Innovation

QUESTIONNAIRE

This Questionnaire on energy efficiency is in partial fulfilment for the award of a Master of technology degree in Environmental management.

Staff ☐ Student ☐

Energy Efficiency

1. The temperature in library is cold

Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐

2. I always like to put on a jacket anytime I study in library

Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐

3. Temperature in library is very conducive for study

Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐

4. Temperature should be raised (**less cold**)

Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐

5. Temperature should be reduced (**colder**)

Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐

6. I notice books in library has dust/ molds on them?

Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐

7. There are too many light bulbs in the library

Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐

8. We should add more lighting (bulbs)

Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐

9. Sometimes I leave my computer plugged more than 20 minutes without use

Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐

10. We should put energy use stickers to remind people to turn off their personal computers when not in use

Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐