CARBON FOOTPRINT CALCULATOR FOR A TYPICAL CAMPUS IN MALAYSIA USING LIFE CYCLE ASSESSMENT APPROACH

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Special gratitude to my beloved family and friends for such incredible love, motivations, and support...

~ No pain no gain ~

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ABSTRACT

In the history of climate change issue, human activities have been documented as a devotee in accelerating the increase number of greenhouse gases (GHGs) in the atmosphere. The subject has grown in importance to estimate and monitor GHGs emission from various activities. In this study, Information Communication Technology-based (ICT-based) software is developed to estimate GHG from campus activities since there is no interactive calculator yet to reliably measure it. The GHGs evaluation is performed using gateto gate life cycle system boundary. Normalization for population and total building space occupied were used to represents the distribution of carbon emissions for different sources over time period. The data from various activities in Universiti Teknologi Malaysia (UTM) includes electricity, transportation, wastewater, solid waste, and fertilizer for 2 years period (2009-2010) is used to evaluate the effectiveness of the carbon calculator. It was found that the results obtain from the carbon calculator is agreed with the sustainable initiative in UTM.

ABSTRAK

Dalam sejarah perubahan iklim dunia, aktiviti manusia telah dikenal pasti antara penyumbang utama dalam mempercepatkan kadar peningkatan gas rumah hijau (GHGs) dalam atmosfera. Situasi ini telah membuka ruang kepada pentingnya untuk menganggar dan memantau kadar pelepasan GHGs dari pelbagai aktiviti yang dijalankan oleh manusia. Dalam kajian ini, perisian berasaskan Teknologi Komunikasi Maklumat (ICT) dibangunkan untuk menganggar kadar pelepasan GHGs daripada aktiviti-aktiviti yang dijalankan oleh kampus memandangkan masih belum ada kalkulator yang interaktif untuk mengukurnya. Penilaian GHGs dilakukan menggunakan sempadan kitaran hidup sistem pintu ke pintu. Normalisasi menggunakan jumlah populasi dan ruang bangunan yang diduduki telah digunakan untuk mewakili taburan pelepasan karbon bagi setiap sumber sepanjang tempoh masa kajian. Data yang diperolehi daripada pelbagai aktiviti yang dijalankan didalam Universiti Teknologi Malaysia (UTM) adalah seperti elektrik, pengangkutan, air sisa, sisa pepejal, dan penggunaan baja sepanjang tempoh 2 tahun kajian (2009-2010) telah digunakan untuk menilai keberkesanan pengukuran menggunakan kalkulator karbon yang dibangunkan. Hasil kajian mendapati bahawa keputusan penganggaran kadar pelepasan GHGs menggunakan kalkulator karbon selari dengan inisiatif kampus lestari yang telah dijalankan didalam UTM.

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LIST OF ABBREVIATIONS

AASHE	-	Association for the Advancement of Sustainability in Higher Education
AMCEN	-	The African Ministerial Conference on the Environment
CCAP	-	Clean Cool Air Planet
CF	-	Carbon Footprint
CFCs	-	Chlorofluorocarbons
CH_4	-	Methane
CO_2	-	Carbon Dioxide
$CO_{2\text{-}e}$	-	Carbon Dioxide Equivalents
EMS	-	Energy Management System
EPA	-	Environmental Protection Agency
JICA	-	Japan International Cooperation Agency
FKK	-	Faculty of Chemical Engineering
FKKKSA	-	Faculty of Chemical Engineering & Natural Resources
GHGs	-	Greenhouse Gases
GWh	-	Gigawatt Hours
GWP	-	Global Warming Potential
HFCs	-	Hydrofluorocarbons
HVAC	-	Heating, Ventilation, and Cooling
IPCC	-	Intergovernmental Protection Climate Change
ISO	-	International Organizations for Standardization's
kg	-	Kilogram
KPI	-	Key Performance Index
kWh	-	Kilowatt Hours

LCA	-	Life Cycle Assessment
LCI	-	Life Cycle Inventory
LCIA	-	Life Cycle Impact Assessment
MMBtu	-	Million Metric British Thermal Unit
MTCDE	-	Metric Tonne Carbon Dioxide Equivalent
NGA	-	National Greenhouse Account
N_2O	-	Nitrous Oxide
NO_2	-	Nitrous Dioxide
PROSPECT	-	Process System Engineering
PFCs	-	Perfluorocarbons
RTM	-	Radio Televisyen Malaysia
STARS	-	The Sustainability Tracking, Assessment, and Rating Systems
TNB	-	Tenaga Nasional Berhad
UNEP	-	United Nation Environmental Protection
UNFCCCCDIAC	-	United nation Framework Convention on Climate Change-Diffusion of Climate Change Technology
UTM	-	Universiti Teknologi Malaysia
WBCSD	-	World Resources Institute and World Business Council on Sustainable Development
WHO	-	World Health Organization
^oC	-	Degree Celcius

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CHAPTER 1

INTRODUCTION

1.1 Study Background

Reported by Horne *et al.* (2009), World Resources Institute and World Business Council on Sustainable Development (WBCSD) 'Greenhouse Gas Protocol' and International Organizations for Standardization's (ISO) are two former methodologies widely used to measure the amount of greenhouse gases (GHGs) generated in an organization or system. Both framework measures the gases emission from sources origination and categorized from 1 to 3 depending on the control ability to the source. Although impressive, many researchers argue that the frameworks experienced tedious GHGs emissions measurement and heightened double counting/credits problem.

Life cycle assessment (LCA) is an alternative method to calculate the GHGs which measuring all elements/sources of GHGs as referred to one functional unit. This one reference helps the assessor to avoid the double measurement of the anthropogenic gases thus giving optimum data quality for the global warming potential created by the studied system (European Commission and Research Centre Environment for Environment and Sustainability, 2010 and Baldo *et al.*, 2000).

With regards to university, the Association for the Advancement of Sustainability in Higher Education (AASHE) (2012) through it STARS (The Sustainability Tracking, Assessment, and Rating Systems) program have received number participants with a lot of interest comes from the European and Americas campus to established their sustainability leadership. Yet in Asia, with focus to Malaysia the higher institution is still in the early stage of promoting the green campus. Green community initiatives through reduction in GHGs emissions will give a positive recognition to the institution.

1.2 Statement of Problem

Although researches abounds with the focus on the development of methodologies and framework for the carbon accounting, the former methodologies are still experienced a difficulty in quantify the greenhouse gases emission. In addition, numerous existence online carbon footprint calculators developed by government and non-government organization are more focusing on household uses.

To date, excel spreadsheet developed by Clean Cool Air Planet (CCAP) is the solitary calculator available to measure GHGs emission in university. The calculator is made up from the tedious application of source origination frameworks using empirical study across universities from developed countries (CCAP, 2006). Such exposition is unsatisfactory because the GHG Protocol measurement used leads to the complex GHGs origin sources determination. Moreover university in developing and poor Asian countries is significantly different technologically and geographically thus adversely affect the measurement of GHGs emissions for Asia region.

Lack of simple, sophisticated, and user-friendly tool from the CCAP calculator to quantify the gases emission has highlighted the importance of this study. For that reason this work has aim to develop an interactive carbon footprint calculator from LCA approach. Universiti Teknologi Malaysia (UTM) is choosing as a generic model to represent a typical higher education institution for Asian poor to developing countries. The added toolkit is beneficial for university from poor and developing countries to plan their carbon management and execution.

1.3 Objectives of Study

This study seeks to develop carbon footprint calculator for a typical campus in Malaysia using LCA approach. The following objectives have been set to address the goal as listed below:

i. To assess major activities lead to GHGs emissions in university campus.

ii. To estimate the GHGs emitted from various activities in university using gate to gate LCA approach.

iii. To quantify total emissions of GHGs generated by UTM.

iv. To develop interactive carbon footprint calculator interface.

1.4 Scope of Research

The study is conducted for the GHGs that are within UTM control ability to the sources. The following are designated scope of study to support objective of the study.

i. A simplify LCA method is use to generate a framework for typical campus operation in Malaysia using gate to gate level system boundaries. The factors that contributed to greenhouse gases emission in UTM is identified and measured to represent the GHGs emitted from its system to the environment.

ii. Emission in UTM is quantified from several sectors as listed below:

- Electricity
- Transportation
- Solid waste and wastewater (generated from various activities in UTM)
- Fertilizer application (agriculture)
- Others (population and physical size of the campus)

Data collection from 2009 to 2010 is taking as case study to cover the UTM Sustainable Campus transformation plan made at end 2009.

iii. The emission of greenhouse gases generated by the university is calculated using carbon footprint as the environmental indicator to measure the global warming potential UTM add to the environment.

iv. The carbon footprint calculator employ Visual basic as a front-end and SQL Server as back-end for the database. The interface is developing to make it attractive and user friendly in the quantification of GHGs emission.

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