DEVELOPMENT OF CARBON FOOTPRINT QUANTIFICATION AND REDUCTION (CAFQUAR) ASSESSMENT TOOL FOR SELECTED NON-RESIDENTIAL BUILDINGS

ABDULLAHI MOHAMMED USMAN

A thesis submitted in
fulfillment of the requirement for the award of the
Doctor of Philosophy

Faculty of Mechanical and Manufacturing Engineering
Universiti Tun Hussein Onn Malaysia

MARCH 2019

DEDICATION

This work is dedicated to my parents, wife, children, brothers and sisters

ACKNOWLEDGEMENT

All praises are due to Allah SWT, I thank Him and seek for His help and forgiveness and I seek refuge from the weakness of my soul and all my shortcomings. After that, I am grateful to Allah for seeing me through every success in my life. I wish to express my sincere appreciation to my supervisor Dr. Mohammad Kamil bin Abdullah for his total and indefinite support and guidance throughout the programme and all my Malaysian days. I am also grateful to my parents Mai Unguwa Muhammad Usman and Malama Aishatu Aliyu Mayodaga, my wife Amina Mohammed Baba, my brother Suleiman Mohammed and all my families for their support toward every success in my life.

My sincere gratitude also goes to Modibbo Adama University of Technology (MAUTECH), Yola and Tertiary Education Trust Fund (TETFund) for their financial support from Academic Staff Development Grant and the University Tun Hussein Onn Malaysia and Research Management Centre (RMC) also for their financial support through Research Assistantship Grant (No. U725).

My thanks goes to Alhaji Umar Hamman Tukur Ribadu, Alhaji Muhammad Yelwa Daudu and Prof Abdullahi Yusuf Ribadu for their immense contributions through financial support and career guidance throughout my tertiary education life. Finally my sincere gratitude goes to all staff and students of Centre for Energy and Industrial Environment Studies (CEIES) specifically Dr Mohd Faizal bin Mohideen Batcha, Dr. Akmal Nizam bin Mohammed, Mohd Hazim Fadli bin Aminnudin and Haswira Bin Hassan. To my friends Adamu Bello Usman, Yahaya Musa, Hijab Mahmood, Nura Usman, Mansur Dodo and many more especially those we stayed together during my PhD study.

ABSTRACT

Greenhouse Gas (GHG) emission is the major consequences of industrial revolution, technology advancement and urbanisation. Building is one of the major factor of these and hence one of the major contributor to global GHG emissions. To ensure sustainable recognition in the building sector, several assessment tools were developed. Some of these tools assessed the sustainability of built environment and others quantify either water, energy, transport or greenery associated emissions hence partially capture building life cycle phase categories. The study aimed at developing an assessment tool for assessing building design emission reduction and operational emission quantification and reduction covering energy, water, transportation, waste and greenery as categories. These categories, parameters and points allocation were obtained from reviewing literatures (eleven rating systems and international standards and reports) and were divided into 27 parameters and 70 sub-parameters. The buildings are graded with star rating and together with the points allocation are distributed to a maximum of 100 Points. The performance of the tool was evaluated by considering the tool feasibility, measurability, applicability, relevancy and its compliance with international standards. These criteria were explained in the pilot and case studies assessment, comparison with other tools and consultation with stakeholders. The pilot and case study assessment cover library, four academics, and office buildings. Some of the case studies have an excellent performance grade which can be seen from their net Carbon Footprint (CFP) and carbon indexes results. This defines the tool ability to compute the net building operational GHG emission and emission density over the total floor area. These processes and criteria fulfilment describe the tools potentials in covering wider scope in relation to GHG emission in term of categories, parameters and its application to variety of non-residential buildings. It is the first tool that consider quantification of all the emission sources categories of the operational phase. The tool is useful to industries for emission quantification and reduction and to government for monitoring their industrial compliance to policies and standards.

ABSTRAK

Pelepasan Gas Rumah Hijau (GHG) adalah disebabkan dari revolusi industri, kemajuan teknologi dan urbanisasi. Bangunan merupakan salah satu faktor utama dan ianya juga salah satu penyumbang utama kepada pelepasan GHG secara global. Untuk memastikan pengiktirafan berterusan dalam sektor bangunan, beberapa alat penilaian telah dibangunkan. Sesetengah alat ini menilai kemampanan persekitaran yang dibina dan juga mengukur air, tenaga, pengangkutan atau penghijauan yang berkaitan dengan pelepasan gas ini dan sebahagiannya merangkap kategori fasa kitaran hayat bangunan. Kajian ini bertujuan untuk membangunkan alat penilaian untuk menilai pengurangan pelepasan dari rekabentuk bangunan serta pelepasan dan pengurangan dari operasi yang meliputi kategori tenaga, air, pengangkutan, sisa dan kehijauan. Dari kategori ini, parameter dan peruntukan mata diperoleh daripada kajian literatur (sebelas sistem penarafan dan piawaian antarabangsa dan laporan) dan dibahagikan kepada 27 parameter dan 70 sub-parameter. Bangunan ini dinilai dengan rating bintang dan juga dengan peruntukan nilai mata yang mana mempunyai nilai maksimum iaitu 100 mata. Prestasi alat penilaian ini dinilai dengan mempertimbangkan kebolehlaksanaan alat, ukuran, kebolehgunaan, relevansinya dan pematuhannya dengan piawaian antarabangsa. Kriteria ini dijelaskan dalam penilaian kajian kes, perbandingan dengan alat penilaian yang lain dan perundingan yang dilaksanakan dengan pihak berkepentingan. Penilaian kajian kes ini meliputi bangunan perpustakaan, empat bangunan akademik dan bangunan pejabat. Sebahagian kajian kes mempunyai gred cemerlang yang boleh dilihat dari nilai *Carbon Footprint* (CFP) dan hasil indeks karbon. Ini menunjukkan keupayaan alat ini untuk menilai pelepasan GHG bersih dari bangunan dan ketumpatan pelepasan melawan keluasan lantai. Proses dan kriteria ini menggambarkan potensi alat penilaian ini dalam meliputi ruang lingkup yang lebih luas berkaitan dengan pelepasan GHG dari segi kategori, parameter dan penggunaanya dalam pelbagai jenis bangunan bukan kediaman. Ini adalah alat pertama yang menganggap kuantifikasi semua sumber pelepasan sumber fasa operasi. Alat ini berguna untuk industri bagi mendapatkan kuantiti dan pengurangan pelepasan dari bangunan dan ianya dapat membantu kerajaan untuk memantau pematuhan pihak industri terhadap dasar dan piawaian yang telah ditetapkan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

CF	- Control Factor
D,d	- Distance in (m)
ETR_0	- Reference Evapotranspiration Rate
F_{cl}	- Ratio of Body Surface Area (fully cloth and when nude)
H_c	- Convection Heat Transfer Coefficient
I_{cl}	- Thermal Resistance of Clothing
IE	- Irrigation Efficiency
K	- Thermal Conductivity of a Material
K_{MC}	- Microclimate Factor
kPa	- Kilo Pascal
Ks	- Species Factor
M	- Metabolism
OF	- Solar Orientation Factor
Pa	- Partial Water Vapour Pressure
Q	- Heat Transfer by a Material
R	- Thermal Resistance
SC	- Shading Device of Fenestration System
T	- Temperature
T_a	- Average Air Temperature
T_{cl}	- Surface Temperature of Clothing
T_{mrt}	- Mean Radian Temperature
U_f	- Thermal Transmittance of Fenestration System
U_w	- Thermal Transmittance of Opaque Wall
V_a	- Average Velocity of Air
W	- External Work
α	- Solar Absorptivity of the Opaque Wall
#	- Percentage Increase

*	- Space to be filled by the assessor
**	- Redistribution of all the parameters and points allocation
***	- Parameters and sub-parameters affected after review
ACEM	- Association of Consulting Engineers Malaysia
AR	- Assessment report
AR5	- Fifth Assessment Report
AWT	- Average Waiting Time
BCI	- Overall Building Carbon Index
BEAM	- Building Environment Assessment Method
BECI	- Building Energy Carbon Index
Breeam	- Building Research Establishment Environment Assessment Method
BTCI	- Building Transportation Carbon Index
BWACI	- Building Waste Carbon Index
BWCI	- Building Water Carbon Index
CAFQUAR	- Carbon Footprint Quantification and Reduction Assessment Tool
CFET	- Carbon Footprint Estimation Tools
CFP	- Carbon Footprint
CO_2e	- Carbon Dioxide Equivalent
DA	- Day Light Access
EDF	- Equivalent Doorstep Frequency
EF	- Emission Factor
FAR	- First Assessment report
FAR	- Fourth Assessment Report
FKAAS	- Faculty of Civil and Environmental Engineering
FPTP	- Faculty of Technology and Business Management
FPTV	- Faculty of Vocational and Technology Education
FSKTM	- Faculty of Computer Science and Information Technology
GBI	- Green Building Index
GESI	- Greenery Emission Sequestration Index
GHG	- Greenhouse Gas
GreenRE	- Green Real Estate
GWP	- Global Warming Potential
IPCC	- Intergovernmental Panel on Climate Chance
JKR	- Ministry of Public Works

REFERENCES

Abdullah, N. I. (2015, December 18). Malaysians need to reduce water consumption. *Malaysiakini*. p. 1-3. Retrieved from www.malaysiakini.com/letters/323856#

AbdurRahman, A. (2017). *Enironmental Sustainability and MyCrest.* Kuala Lumpur: 4th Awareness Course on Enironmental and Sustainability.

Abolore, A. A. (2012). Comparative Study of Environmental Sustainability in Building Construction in Nigeria and Malaysia. *Journal of Emerging Trends in Economics and Management Sciences (JETEMS), 3*(6), pp. 951 - 961.

Adegbile, M. B. (2013). Assessment and Adaptation of an Appropriate Green Building Rating System for Nigeria. *Journal of Environment and Earth Science, 3*(1), pp. 1-11.

Ahankoob, A., Moeshedi.E, S. R. and Rad, K. G. (2013). A Comprehensive Comparison between LEED and BCA GreenMark as Green Building Assessment Tools. *The International Journal Of Engineering And Science (IJES), 2*(7), pp. 31-38.

Ali, H. H. and Al Nsairat, S. F. (2009). Developing a Green Building Assessment Tool for Developing Countries – Case of Jordan. *Building and Environment, 44*, pp. 1053-1064.

Almeida, H. S. (2010). *Thermal Comfort Analysis of Building Using Theoretical and Adaptive Models.* Lisboa: Instituto Superior Technico.

Anand, M. and Sing, S. S. (Ed.) (2016). *About Indian Green Building Council*. Hyderabad, Indian Green Building Council

Arup and De Montfort University. (2012). *Measuring scope 3 carbon emissions – water and waste A guide to good practice.* London: Higher Educatio Fundings of England.

ASHRAE (2013). *Thermal Environmental Condition for Human Ocupancy.* Atlanta USA: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Augenbroe, G. L. M., Pearce, A. R. (2000). Sustainable construction in the USA: A perspective to the year 2010. *proceeding of the International Conference on World Futures,* Sri Lanka. pp. 22–25.

Avestian, H. G., Hools, E, M. and Melanta, S. (2012). Decision Models to Support GHG Emissions Reduction from Transportation Construction Projects. *Journal of Construction Engineering and Management*, *138(5),* 631-641.

Bahaudin, A. Y. Elias, E. M. and Saifudin, A. M. (2014). A Comparison of the Green Building's Criteria. *Proceedings of E3S Web of Conferences* Kuala Lumpur. pp. 1-10. EDP Sciences.

Bari, M. A., Begum, R, A., Nesadurai, N. and Pereira, J. J. (2015). Water Consumption Patterns in Greater Kuala Lumpur: Potential for Reduction. *Asian Journal of Water, Environment and Pollution,, 12(3),* 1 - 7.

Building and Construction Authority. (2004). *Guidelines on Envelope Thermal Transfer Value for Building.* Singapore: Building and Construction Authority.

BEAM Society Limited. (2017). *BEAM Plus Building Assessment Tools.* Hong Kong: BEAM Society Limited.

Beizaee, A. and Firth, S. K. (2011). A Comparison of Calculated and Subjective Thermal Comfort Sensation in Home and Office Environment. *Proceedings of Conference: People and Buildings: Network for Comfort and Energy Use in Buildings*, London. (pp. 1-6).

Beizaee, A., Firth, S. K., Vadodaria, K. and Loveday, D. (2012). Assessing the Ability of PMV Model in Predicting Thermal Sensation in Naturally Ventilated Buildings in UK. *Proceedings of 7th Windsor Conference: The Changing Context of Comfort in an Unpredictable World.* London. pp. 1-17. Network for Comfort and Energy Use in Buildings.

Bernstein, H. M., Russo, M. A., Fitch, E. and Laquidara, D. (Ed). (2013). *World Green Building Trends: Business Benefits Driving New and Retrofit Market Opportunity in Over 60 Countries, A Smart Market Report.* World Green Building Council and United State Green Building Council. Bedford, Boston: McGraw Hill Construction and United Tecnologies.

Bhortake, S. and More, A. (2016). Awareness of Leed Rating System Credit Categories for Green Buildings Applications to the Existing Building. *International Journal of Engineering Research and Development, 12(5)*, 08-14.

Bisegna, F., Mattoni, B., Gori, P., Asdrubali, F., Guattari, C., Evangelisti, L., Sambuco, S. and Bianchi, F. (2016). Influence of Insulating Materials on Green Building Rating System Results. *Energies, 9*, 1-17.

Biswas, W. K. (2014). CFP and Embodied Energy Consumption Assessment of Building Construction Works in Western Australia. *International Journal of Sustainable Built Environment, 3*, 179-186.

Blais, A. M., Lorrain, S., Plourde, Y. and Varfalvy, L. (2005). Organic Carbon Densities of Soils and Vegetation of Tropical, Temperate and Boreal Forests. In V. L. Tremblay A., *GHG Emissions - Fluxes and Processes. Environmental Science* pp. 155-185. Berlin, Heidelberg. Springer.

Bodansky, D. (2010). *The Copenhagen Climate Change Conference: A Post-Mortem.* Geogia: University of Geogia, School of Law.

BREEAM (2017). *Breeam Rating System Technical Manual*. Watford, London, Research Establishement Environmental Assessment Method. Retrieved from Breeam: http://www.breeam.com/technical-standards

Bremer, L. V. (2009). *Space Allocation Standar Manual.* Washington: General Administration State of Washington.

Center for Climate and Energy Solutions. (2015). *Outcomes of the U.N. Climate Change Conference in Paris: 21st Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 21).* Arlington: Centre for Climate and Energy Solutions.

Construction Industries Development Board (CIDB) Malaysia. (2017). *Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST).* Kuala Lumpur: Construction Industries Development Board.

CIDB Malaysia. (2018, 7). *Construction Industries Development Board*. Kuala Lumpur. Retrieved from My Crest: http://www.cidb.gov.my/

Cubasch, U., Wuebbles, D., Chen, D., Facchini, M. C., Frame, D., Mahowald, N. and Winther, J. G. (2013). Introduction. In C. Change, *The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* pp. 119-158. Cambridge and New York. Cambridge University Press.

Davis, H. S. and Paulsboro, N. J. (1993). Initian Absorption Rates of Carbon Dioxide by Water and Dilute Sodium Carbonate Solution. *Industraial and Engineering Chemistry, 25*(9), 1023-1025.

Department of Statistics Malaysia. (2017). *Key Statistics of Population Demography 2017.* Kuala Lumpur: Department of Statistics Malaysia. Retrieved from https://www.dosm.gov.my

Dorji, T,. Odeh, . I. O. A. and Field, J. D. (2014). Vertical Distribution of Soil Organic Carbon Density in Relation to Land Use/Cover, Altitude and Slope Aspect in the Eastern Himalayas. *Land, 3*, 1232-1250.

Driedger, M. (2009). Choosing the Right Green Building Rating System: An Analysis of SixRating Systems and They Measure Energy. *Perkins+Will Research Journal, 1(1)*, 22-41.

Edwards, R. (2014). *WHO Indoor Air Quality Guidelines: Household fuel Combustion.* Geneva, Switzerland: World Health Organisation. Retrieved from http://www.who.int/airpollution/guidelines/en/

Energy Commission. (2014). *Malaysian Energy Statistics Hand Book 2014.* Kuala Lumpur: Energy Commission Malaysia.

EPA. (2014). *Emission Factors for GHG inventories.* Washintong, U.S Environmental Protection Agency.

Erbach, G. (2015). *Doha Amendment to the Kyoto Protocol: At a Glance.* European Parliamentary Research Service (EPRS).

Evans, M., Shui, B. and Takagi, T. (2009). *Country Report on Building Energy Codes in Japan.* Washington. U.S. Department of Energy.

Fanger, P. O. and Toftum, J. (2002). Extension of the PMV Model to Non-Air Conditioned Building in Warm Climated. *Energy and Building*, 533-536.

Fenner, R. A. and Ryce. T. (2011). A Comparative Analysis of Two Building Rating System. *Engineering Sustainability*. 161(ES1), 55-63. from *Proceedings of the Institution of Civil Engineers.*

Fowler, K. M. and Rauch, E. M. (2006). *Sustainable Building Rating Systems Summary.* Richland. Pacific Northwest National Laboratory Operated for the U.S. Department of Energy by PNNL-15858.

Gallali, T., Brahim, N. and Bernoux, M. (2010). Soil Organic Carbon Density and Storage in Tunusia. *19th World Congress of Soil Science, Soil Solutions for a Changing World 1 – 6 August 2010*, Brisbane, Australia. pp. 24-27.

Green Building Council Australia. (2017a). *Energy Consumption and GHG Emissions Calculation Guide.* Sydney: Green Building Council of Australia.

Green Building Council Australia. (2017b). *home.* Sydney: Green Building Council of Australia.

Green Building Council Canada. (2009). *Guidance on Calculation of Outdoor Water Use Reductions for LEED Canada for Homes Credits SS 2.5 and/or WE 2.3.* Toronto, Green Building Council Canada.

Green Building Council Indonesia. (2016). *About GBC Indonesia.* Jakarta: Green Building Council Indonesia.

Green Building Council Indonesia. (2015). *GreenShip Rating and Certification Tool Summary.* Jakarta: Green Building Council Indonesia.

Green Building Council Souh Africa. (2013). *International Framework for Socio-Economic Factors for Green Building Rating Tools in Developing Countries.* Cape Town: Green Building Council Souh Africa and World Green Building Council.

GBI. (2017). *Green Building Index Rating Systems.* Kuala Lumpur: Green Buuilding Index Bhd, Sdn. Retrieved from: www.greenbuildingindex.org

Green Building Index Home. (2017). *Green Building Index*. Retrieved 04 23, 2016, from Green Building Index: www.greenbuildingindex.org

GHG Protocol. (2001). *GHG Protocol: Corporate Accounting and Reporting Standard.* Geneva: World Resource Institute (WRI) and World Business Council for Sustainable Development (WBCSD).

GHG Protocol. (2004). *GHG Protocol: A Corporate Accounting and Reporting Standard-Revised Edition.* Washington: World Resources Institute and World Business Council.

GHG Protocol. (2005). *GHG Protocol Project Accounting and Reporting Standard.* Washington: World Resources Institute and World Business Council for Sustainable Development.

GHG Protocol. (2006). *The Land Use, Land-Use Change, and Forestry (LULUCF) Guidance for GHG Project Accounting.* Washington: World Resources Institute.

GHG Protocol. (2011). *GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard.* Washington: World Resources Institute and World Business Council for Sustainable Development.

GHG Protocol. (2011b). *GHG Protocol: Product Life Cycle Accounting and Reporting Standard.* Washinrton: World Resources Institute and World Business Council for Sustainable Development.

GHG Protocol. (2014). *Global Protocol for Community-Scale GHG Emission Inventories (GPC.* Washington: World Resources Institute.

GHG Protocol. (2014c). *Mitigation Goal Standard: An Accounting and Reporting Standard for National and Subnational GHG Reduction Goals.* Washington: World Resources Institute.

GHG Protocol. (2016a). *Standard*. Washington, World Resources Institute. From Green House Gas Protocol: http://www.ghgprotocol.org/standards/corporate-standard

GHG Protocol. (2016b). *Emission Calculation Tools*. Washington WorlRetrieved from Green House Gas Protocol: http://www.ghgprotocol.org/calculation-tools

Green Mark. (2017). *BCA Green Mark Assessment Scheme.* Singapore: Building and Construction Authority.

Green Star. (2016). *Green Star Australia Rating Systems.* Sydney: Green Building Council Australia. Retrieved from www.new.gbca.or.au

Green Star. (2017a). *Green Star Australia Rating Systems.* Sydney: Green Building Council Australia. Retrieved from www.new.gbca.or.au

Green Star. (2017b). *Green Star GHG Emission Calculator Guide.* Sydney: Green Guilding Council Australia.

Green Star Australia. (2017a). *Access by Public Transport Calculator Guide.* Sudney: Green Building Council Australia.

Green Star New Zealand. (2016). *Green Star Technical Manual Version 3.1.* Wellington: New Zealand Green Building Council.

Green Star New Zealand. (2017). *Green Star Technical Manual Version 3.1.* Wellington: New Zealand Green Building Council.

Green Star South Africa. (2014). *Green Star SA – Socio-Economic Category: Fact Sheet.* Johanesburg: Green Building Council South Africa.

Green Star South Africa. (2017). *Green Star South Africa Building Rating Systems.* Cape Town: Green Building Council South Africa.

GreenRE. (2017). *GreenRE Rating Systems.* Kuala Lumpur: Real Estate and Housing Development Association of Malaysia. Retrieved from www.greenre.org

GreenShip. (2017a). *GreenShip Indonesia Building Rating Systems.* Jakarta: Green Building Council Indonesia. Retrieved from http://gbcindonesia.org/greenship

GreenShip. (2017b). *GreenShip Rating Tools and Certification*. Retrieved from Green Building Council Indonesia: http://www.gbcindonesia.org/

Happold. (2016). *Life Cycle Assessment (LCA).* London UK: Designing Buildings Ltd.

Hedaoo, M. N. and Khese, S. R. (2016). A Comparative Analysis of Rating Systems in Green Building. *International Research Journal of Engineering and Technology (IRJET), 3*(6), 1393-1399.

Hee, L. (2013). *Greening Singapore's Built Environment.* Singapore: Building and Constrcution Authority.

Heyward, O. J. (2011). *Climate Change Mitigation Through Strategic Planning in Local Government.* Tasmania: University of Tasmania.

Hong Kong Green Building Council (HKGBC). (2016). *BEAM Plus*. Hong Kong Green Building Council. Retrieved from https://hkgbc.org.hk/eng

Hoornweg, D., Sugar, L. and Gomez, C. L. T. (2011). Cities and GHG Emissions: Moving Forward. *Environment Urbanization, 23(1),* 1-21.

Indian Green Building Council (IGBC). (2016). *Green Building Movement in India*. Hyderabad, Indian Green Building Council. From https://igbc.in/igbc/r

Indian Green Building Council. (2017). *IGBC Rating Systems.* Hyderabad. Indian Green Building Council, From https://igbc.in/igbc/.

IPCC. (2006b). *Energy: 2006 IPCC Guidelines for National GHG Inventories, Prepared by the National GHG Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds).* Kamiyamaguchi, Hayama, Kanagawa, Japan: Institute for Global Environmental Strategies (IGES), Hayama, Japan.

IPCC. (2013). *Climate Change 2013: The Physical Science Basis Report. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* . Cambridge Uk and New York USA. Cambridge University Press. Retrieved from ww.ipcc.ch.

IPCC. (2014). *2013 Suppliment to the 2006 IPCC Guidelines National GHG Inventories.* Geneva. Intergovernmental Panel on Climate Change (IPCC).

IPCC. (2014a). *Climate Change Fiveth Assessment Reports 2014.* Geneva: Intergovernmental Panel for Climate Change.

IPCC. (2014b). *Climate Change 2014: Impacts, Adoption and Vulnerability Report.* Geneva. Intergovernmental Panel on Climate Change. Retrieved from www.ipcc.ch

IPCC. (2014c). *Climate Change 2014: Mitigation of Climate Change Report 2014.* New York. Intergovernmental Panel on Climate Change. Retrieved from www.ipcc.ch

IPCC. (2015a). *IPCC Factsheet: Timeline – highlights of IPCC history.* Geneva. Intergovernmental Panel on Climate Change. Retrieved from www.ipcc.ch

IPCC. (2015b). *The IPCC Fifth Assessment Report (AR5) Leaflet.* Geneva. Intergovernment Panel on Climate Change. from www.ipcc.ch

IPCC. (2016). *Home, Activities and Assessment reports*. Geneva. Retrieved from Intergovernmental Panel on Climate Change (IPCC). from www.ipcc.ch

IPCC. (2016). *Special Report on impacts of global warming of 1.5 °C (SR1.5).* Geneva. International Panel on Climate Change (IPCC). from https://www.ipcc.ch

IPCC AR4. (2007). *IPCC Fourth Assessment Report: Climate Change 2007.* Cambridge and Geneva. Cambridge University Press for Intergovernmental Panel on Climate Change.

IPCC FAR. (1990). *IPCC First Assessment Report: Climate Change 1990.* Cambridge and Geneva. Cambrige University Pree for Intergovernmental Panel for Climate Change (IPCC).

IPCC SAR. (1996). *IPCC Second Assessment Report: Climate Change 1995.* Cambridge and Geneva. Cambridge University Press for Intergovernmental Panel for Climate Change.

IPCC TAR. (2001). *IPCC Third Assessment Report: Climate Change 2001*. Cambridge and Geneva. Cambridge University Press for Intergovernmental Panel on climate Change.

IPIECA. (2002). *A Guide to the Intergovernamental Panel on Climate Change (IPCC).* London: International Petroleum Industry Environmental Conservation Association.

KeTTHA. (2016a). *History of the Ministry*. Putrajaya, Ministry of Energy, Green Technology and Water (KeTTHA). Retrieved from www.kettha.gov.my.

KeTTHA. (2016b). *The National Freen Technology Policy Report.* Putrajaya. Ministry of Energy, Green Technology and Water. Retrieved from www.kettha.gov.my.

Khasreen, M. M., Banfill, P. F. G. and Menzies, G. F. (2009). Life-Cycle Assessment and the Environmental Impact of Buildings: A Review. *Sustainability, I*, 674-701.

Kortman, J., Ewijk, H. V., Mak, J., Anink, D. and Knaph, M. (1998). Presentation of Eco-Quantum, the LCA-Based Computer Tool for the Quantitative Determination of Environmental Impact of Buildings. *Proceedings of CIB World Building Congress.* Gaevle, Sweden, World Building Congress pp 1-9.

Kshirsagar, B., Mane, V., Saharkar, U. and Salumke, H. (2015). Comparative Analysis of Green Building Rating Systems. *International Journal of Engineering Technology, Management and Applied Sciences, 3(2)*, 287-296.

Lee, J. (2009). *Green Building Index Malaysia.* Kuala Lumpur, Integrated Environmental Solutions Limited. Retrieved April 23, 2016, from: wwwblog.iesve.com/index.php/2009/08/24/green-buildin-index-malaysia

LEED. (2017). *LEED Rating Tools for Different Types and Stages of Buildings.* Washington: United State Green Building Council. Retrieved from https://www.usgbc.org/resources/grid/leed

Leggett, J. A. and Carter, N. T. (2012). *Rio+20: The United Nations Conference on Sustainable Development, June 2012.* Rio de Janeiro. Congressional Research Service.

Lide, D. R. (2005). *Water Vapour Pressure from 0 - 370oC In CRC Handbook of Chemistry and Physics Internet Version.* Boca Raton: CRC Press. Retrieved from http://www.hbcpnetbase.com

Lim, J. (2018). *Building Energy Index and Green Building Index Malaysia.* Kuala Lumpur. Retrieved from www.blog.japhethlim.com

Lippiatt, B. C. (2002). *Building for Environmental and Economic Sustainability Technical Manual and User Guide.* Gaithersburg: National Indtitute of Standard and Technology Administration, U.S. Department of Commerce.

Liu, Y., Prasad, D., Li, Y., Fu, Y. and Liu, J. (2005). A Holistic Approach to Developing Regionally Specific Framework for Green Building Assessment Tools in China. *Proceeding of the World Sustainable Building Conference Tokyo, 27-29 September 2005 (SB05Tokyo)*, Tokyo. pp. 1634-1641.

McCullough, E. A., Eckels, S. and Harms, C. (2009). Determining Temperature Ratings for Children's Cold Weather Clothing. *Applied Ergonomics, 40*, 870–877.

Meakin, S. (1992). *The Rio Earth Summit: Summary of the United Nations Conference on Enivironment and Development.* Rio de Janeiro. United Nation.

Melanta, S., Miller-Hooks, E. and Avetisyan, H. G. (2013). Carbon Footprint Estimation Tool for Transportation Construction Projects. *Journal of Construction and Management (JCM), 139*(5), 547-555. 8

Malaysian Green Building Confederation (MGBC). (2017). *Events and Conferences*. Malaysian Green Building Confederation. From. www.mgbc.org.my

Malaysia Green Building Confederation (MGBC). (2018). *About Malaysia Green Building Confederation*. Kuala Lukmpur, Malaysia Green Building Confederation. Retrieved from: http://www.mgbc.org.my/about-mgbc/

Ministry of Natural Resources and Environment (MNRE). (2015). *First Biennial Update Report submitted to the United Nations Framework Convention on Climate Change in December 2015.* Kuala Lumpur: Ministry of Natural Resources and Environment, Malaysia. Retrieved from www.nre.gov.my.

MNRE. (2009). *National Mineral Policy 2: Toward Sustainable Mining.* Putrajaya. Ministry of Natural Resources and Environment Malaysia.

MNRE. (2016). *About Us*. Putrajaya. Ministry of Natural Resources and Environment. Retrieved from www.nre.gov.my.

Mohammad, N. (2011). Environmental Law and Policy Practices in Malaysia: An Empirical Study. *Australian Journal of Basic and Applied Sciences,, 5*(9), 1248-1260.

Mohd Lip, M., Aliman, S. and Termidi, H. (2009). Sustainable Development Initiatives in the Malaysian Minieral Industry. *Proceedings of Asia Pacific Economic Cooperation (APEC) Conference on Sustainable Development of Mining Sector in APEC* Singapore: pp 1-6.

Mohr, P. J. and Taylor, B. N. (2005). Basic Constants, Units and Conversion Factors. In L. D. R., *CRC Handbook of Chemistry and Physics.* Boca Raton: CRC Press. pp. 1.1-1.54.

Department of Standard Malaysia. (2014). *Malaysian Standard: Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings - Code of Practice.* Kuala Lumpur: MS 1525.

Muhidin, M. U. and Kei, H. M. (2017). *Press Release: The Current Population Estimates, Malaysia, 2016 - 2017* . Kuala Lumpur: The Department of Statistic Malaysia.

Mun, T. L. (2009, April 23). *The Development of GBI In Malaysia.* Kuala Lumpur. Green Bulding Index Malaysia: Retrieved from www.greenbuildingindex.org.

Nduka, D. O. and Ogunsanmi, O. E. (2015a). Stakeholders Perception of Factors Determining the Adoptability of Green Building Practices In Construction Projects In Nigeria. *Journal of Environment and Earth Science, 5(2),* 188 - 196.

Nduka, D. O. and Ogunsanmi, O. E. (2015b). Construction Professionals' Perception on Green Building Awareness and Accruable Benefits in Construction Projects in Nigeria. *Covenant Journal of Research in the Built Environment (CJRBE), 3(2),* 30-52.

New Mexico Services Department. (2000). *State of New Mexico Space Standards.* Santa Fe, New Mexico: New Mexico General Services Department, Property Control Division.

Noor, Z. Z., Md Din, M. F., Samanaseh, V. and Che Hassan,C. H. (2015). *Final Report for Three-Year Trend (2012-2014) Assessment of SAJ's CFP.* Johor: Centre of Environmental Sustainability and Water Security, UTM.

Norini, H. and Woon, W. C. (2002). *Policy Trend Report (2002): Trends in Malaysian Forest Policy.* Kuala Lumpur: Forest Research Institute Malaysia.

Nwokoro, I. O., and Onukwube, H. (2011). Sustainable or Green Construction in Lagos, Nigeria: Principle,. *Journal of Sustainble Development, 4(4),* 166-174.

NZHR. (2015). *International Treaty Examination of the Doha Amendment to the Kyoto Protocol.* Wellington: New Zealand House of Representatives (NZHR).

Otegbulu, A. C. (2011). Economics of Green Design and Environmental Sustainability. *Journal of Sustainable Development, 4(2),* 240-248.

Othman, R. and Abu Kasim, S. Z. (2016). Assessment of Plant Materials Carbon Sequestration Rate for Horizontal and Vertical Landscape Design. *International Journal of Environmental Science and Development, 7(6)*, 410-414.

Othman, R., Abu Kasim,S. Z. , Hashim, K. S. H. and Baharuddin, Z. M. (2016). Evakuation of Carbon Reduction through Integration of Vertical and Horizontal Lanscape Design for Hotels Premises. *Journal of Environmental Biology, 37*(*Special Issue*), 1187-1190.

Pagliaro, F., Cellucci, L., Burattini, C., Bisegna, F., Gugliermetti, F., De Lieto Vollaro, A., Salata, F. and Golasi, I. (2015). A methodological comparison between energy and environmental performance evaluation. *Sustainability, 7*, 10324-10342.

Parry M. L., Canziani, O. F. Palutikof, J. P. Van der Linden, P. J. and Hanson, C.E. (Eds). (2007). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambrigde: Cambridge University Press .

Parsons, K. (2017). *Overview of Design Regulations for Thermal Comfort – Reviews and Highlights of Latest Thermal Comfort Standards.* Loughborough: Loughborough University.

Penman, J., Gytarsky, M., Hiraishi, T., Irving, W. and Krug, T. (2006). *2006 IPCC Guidelines for National GHG Inventories.* Geneva: International Panel For Climate Change (IPCC).

Pittenger, D. (2012). How Much Water Does A Landscape Really Need? *2012 Landscape Industry Show Workshop.* California: University of California (Agriculture and Natural Resource Centre).

Raghu, M. (2016, September). *Home Page/About IGBC*. Hyderabad: Indian Green Building Council/ Retrieved from https://igbc.in/igbc/

Ramli, N. H., Haji Masri, M., Haji Mohd Taib, M. Z. and Abd Hamid, N. (2012). A Comparative Study of Green School Guidelines. *Procedia - Social and Behavioral Sciences, 50*, 462 – 471.

Reed, R., Bilos, A., Wilkinson, S. and Schulte, K. W. (2009). International Comparison of Sustainable Rating Too l s. *Journal of Sustainable Research (JOSRE), 1*(*11)*, 1-22.

REHDA. (2013). *REHDA launches its own GreenRE rating tool.* Kuala Lumpur: Star Property Malaysia Retrieved, from www.starproperty.my.

Reppe, P., Scheuer, C. W. and Taylor, M. (2002). *Application and Refinement of Bees For Enhancing Building Life Cycle Assessments.* Michigan: Department of Plant Development. and Centre for Sustainable Systems, University of Michigan.

Rosly, D. (2012). *Advancing the Sustainable Development Agenda Through Aligning Malaysia Plans Policies.* Kuala Lumpur: National Consultation Workshop United Nations Conference On Sustainable Development (UNCSD) 2012.

Sawatzky, J. (2011). *Comparative Analysis of Green Building Rating System LEED NC vs Build Green.* Vancouver: Light House Sustainable Building Centre.

Say, C. and Wood, A. (2008). Sustainable Rating System Around the World. *Council on Tall Buildings and Urban Habitat (CTUBH) Journal*, *11*, 18-29.

Shafie, S. M., Mahila, T. M. I., Masjuki, H. H. and Andriyana, A. (2011). Current Energy Usage and Sustainable Energy in Malaysia: A. Review. *Renewable and Sustainable Energy Reviews*, *15*, 4370-4377.

Shamsuddin, S. and Abdur Rashid, A. (2013). Malaysian Urban and Rural National Indicators Network on Sustainable Development (MURNInets). *Proceeding of 43rd Annual Conference of the Urban Affairs Association (ACUAA) 3-6th April, 2013* (pp. 1-13). San Francisco, Califonia: Urban Affairs Association.

Soni, K. M. (2016). Waste to Resource for Sustainable Development. *Indian Journal of Science and Technology, 9(5)*, 1-6.

Suzer, O. (2015). A comparative Review of Environmental Concern Prioritization: LEED vs other Major Certification. *Journal of Environmental Management, 154*, 266–283.

The Engineering ToolBox. (2018, 05 16). *Building Area per Person.* Retrieved from The Engineering ToolBox: www.engineeringtoolboc.com

Toftum, J. (2005). Thermal Confort Indices: Procedure. In N. H. Stanton, *Handbook of Human Factors and Ergonomics Methods* (pp. 60-1 - 63-11). Boca Raton: CRC Press LLC.

Towell, B. H., Milagre, R. and Cunha, A. (2015). *World Green Building Council Rating Tools Task Group: Quality Assuarance Guide for Green Building Rating Tools.* Toronto: World Green Building Council Rating Tools Task Group. World Green Building Council. Retrieved from www.worldgbc.org

Transport For London. (2010). *Measuring Public Transport Accessibility Levels (PTALs) Summary.* London: Transpot For London.

Umar, A. A. and Khamidi, M. F. (2012). Determined the Level of Green Building Public Awareness: Application and Strategies. *Proceedings of 2012 International Conference on Civil, Offshore and Environmental Engineering, Kuala Lumpur Malaysia*, Kuala Lumpur: pp. 1-6.

United Nations Environmenta Programme (UNEP). (1991). *Handbook for the Montreal Protocol on Substances thet Deplete the Ozone Layer.* Nairobi, Kenya: United Nations Environmenta Programme.

UNEP. (2003). *Handbook for the International Treaties for the Protection of the Ozone Layer (The Vienna Convention 1985 and The Montreal Protocol 1987).* Nairobi Kenya: United Nation Environmental Programme.

UNEP. (2016). *Towards Zero Emission Efficient and Resilient Buildings: Global Status Report.* Paris: Global Aliance for Building and Construction. United Nations Environmenta Programme

UNEP SBCI. (2009). *Building and Climate Change: Summary for Desicion Makers.* Paris: United Nations Environment Programme and Sustainable Buildings and Climate Innitiative.

UNFCCC. (1998). *Kyoto Protocol to the United Nations Framework Convention on Climate Change.* New York: United Nation.

UNFCCC. (2008). *Kyoto Protocol Reference Manual On Acounting of Emissions and Assigned Amount.* Climate Change Secretariat (UNFCCC), Bonn, Germany: United Nations Framework Convention on Climate Change.

UNFCCC. (2010). *Report of the Conference of the Parties on its Fifteenth Session, Held in Copenhagen 2009.* Copenhagen: United Nation.

UNFCCC. (2015). *The Adoption of the Paris Agreement: Conference of the Parties (COP21).* Paris: United Nation.

United Nation Environmental Programme. (2012). *Sustainable Building and Climate Innitiative: Promoting Policies and Practices for Sustainability.* France: United Nation Environmental Programme.

United Nation Sustainable Developent. (1992). *United Nations Conference on Environment Development Rio de Janerio, Brazil, 3 to 14 June 1992.* New York: United Nation Sustainable Developent.

Unites Nation. (2002). *Report of the World Summit on Sustainable Development (Johannesburg, Rio 1).* New York: United Nation.

US-GBC. (2016). *Home*. United State Green Building Council. Retrieved from http://www.usgbc.org/about

Vierra, S. (2014). *Green Building Standards and Certification Systems.* Washington: World Building Design Guide Institute.

Waidyasekara, K. G. A. S., De Silva, M. L. and Rameezdeen, R. (2013). Comparative Study of Green Building Rating Systems: In Terms of Water Efficiency and Conservation. *The Second World Construction Symposium 2013: Socio-Economic Sustainability in Construction*, Colombo, Srilanka. pp. 108-117.

Weiling, W. (2011). *Carbon Footprint: A Case Study on the Municipality of Haninge: A Master of Science in Sustainable Development.* Handen, Sweden: Royal Institute of Technology, KTH STH.

World Green Building Council (WGBC). (2009). *Six Continent One Mission: How Green Building is Shaping the Global Shift to a Low Carbon Economy.* Toronto: World Green Building Council. Retrieved from www.worldgbc.org

WGBC. (2016b). *World Green Building Council Membership.* Toronto: World Green Building Counci. Retrieved from www.worldgbc.org

WGBC. (2016c). *Health, Wellbeing and Productivity in Offices.* Toronto: World Green Building Council.

WGBC. (2016d). *Socio-Economic Framework for Rating Tools*. Toronto: World Green Building Council. Retrieved from www.worldgbc.org/activities/rating-tools/

WGBC. (2016e). *Quality Assuarance of Green Building Ration Tools*. World Green Building Council Retrieved from www.worldgbc.org/activities/rating-tools.

WGBC. (2016f). *World Green Building Council Congress.* Toronto: World Green Building Council.

WGBC. (2017). *About Green Building: The benefits of green buildings.* Toronto: World Green Building Council. Retrieved from www.worldbc.org.

WGBC Report. (2009). *Six Continent One Mission: How Green Building is Shaping the Global Shift to a Low Carbon Economy.* Toronto: World Green Building Council.

Wu, W. (2011). *CFP – a Case Study on the Municipality of Haninge (Masters Thesis).* Stockholm: KTH, School of Technology and Health.

Xiaohuan X., Zhongfang Y., Yujun C., Shumei S., Chengguang Y. and Min L. (2011). A study of Soil Organic Carbon Distribution and Storage in the Northeast Plain of China. *China University of Geosciences (Beijing) Geoscience Frontiers, 2(2),* 115-123.

Xu, Z., Hu, G., Spanos, C. and Schiavon, S. (2017). PMV-Based Event-Triggered Mechanism for Building Energy Management Under Uncertainties. *Building and Energy 152*, 73-85.

Yau, Y. H., Ding, L. C. and Chew, B. T. (2011). Thermal Comfort and Indoor Air Quality at Green Building in Malaysia UMIES. *United Kingdom, Malaysia and Ireland Engineering Science Conference 2011*. Kuala Lumpur: University of Malaya. pp. 1-8.

Zhang, X., Platten, A. and Shen, L. (2011). Green property development practice in China: Costs and barriers. *Building and Environment, 46*, 2153-2160.