Campus Operational Carbon Assessment Based on Low Carbon City Framework (LCCF)

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Abstract.

Universiti Teknologi MARA (UiTM) is Malaysia’s largest institution of higher learning (IHE). The university is based on 13 state campuses and 21 satellite campuses. The state of Selangor has the largest number of UiTM campuses, and the main anchor campus is located in the state capital, Shah Alam. As for UiTM which is committed to implement the low carbon cities framework program focusing on five GHG reduction elements through energy, mobility, waste, water; and greenery and water bodies. This study reveals the carbon operational assessment in UiTM campus located in Shah Alam, Selangor using city-based approach within the Low Carbon City Framework (LCCF) which are; urban environment, urban infrastructure, building criteria.

1. Introduction

Climate change has prompted action around the world to mitigate greenhouse gas (GHG) emissions, as evidenced by the Paris Agreement, United Nations Sustainable Development Goals, as well as local, regional and national initiatives aimed at reducing emissions across all sectors [1]. The Low Carbon Cities (LCC) is defined as a city that comprises of societies that consume sustainable green technology, green practices and emit relatively low carbon or GHG as compared with present-day practice to avoid the adverse impacts on climate change [2]. LCCF is one of the most essential tools applied in local authorities as guiding blueprint for low carbon cities amongst local authority’s community [3]. Most local authorities used LCCF as a self-monitoring tool for management in understanding the realities of the carbon situation, and to make informed decisions or plan internally or locally by familiarizing the carbon emitter variables and easy to adapt by the local community by enhancing their knowledge on how their ‘footprint’ is being determined [4]. Low Carbon City relates to carbon minimization in all sectors by developing a society that emits GHG only in an amount that can be absorbed by nature and achieving a lifestyle that realizes the richer quality of life [2].
Numerous emission reduction measures have been implemented, and considerable efforts have been devoted to promoting low-carbon on campus [5][6]. As a university which can be considered as “small cities” which may have a massive impact on the environment due to their activities, movement of goods and persons inside campuses [6]. [7] define sustainable development for higher education as “a higher educational institution, as a whole or as a part, that addresses, involves and promotes, on a regional or a global level, the minimization of negative environmental, economic, societal, and health effects generated in the use of their resources to fulfil its functions of teaching, research, outreach and partnership, and stewardship in ways to help society make the transition to sustainable lifestyles”. It was observed that high CO2 emission resulted from electricity energy consumption, and the highest emission in the transport sector was produced by commuting vehicles while emission from service delivery for cooling, lighting and other equipment [8]. Thus, the establishment of low carbon assessment initiatives is a crucial task in determining the source of carbon contributed to the campus [8]. Also, the products of direct and indirect activities such as classrooms, laboratories, offices and the consumption of food and drinks generate negative environmental impacts [9]. The combine activities of the global university population constitute significant energy use; hence, universities offer great potential for sustainability practices models of [8][10]. Thus, the study has adopted the city-based approach where criteria within the Low Carbon City Framework (LCCF) which are; urban environment, urban infrastructure, building criteria were assessed in the campus.

2. Methodology

2.1 Study site

Universiti Teknologi MARA (UiTM) has population recorded approximately 31,589 (2013) 35,098 (2014) 38998 (2015) 43,332 (2016) and 47,887 in (2019). The physical characteristic of UiTM covers approximately 47ha of land which consist both areas forest and planted vegetated areas in (Figure 1). The total of 324 buildings are on campus occupied consisting of 16 faculties, 9 colleges and residences and 11 premier buildings and any other buildings [10].

![Forest and planted vegetation](http://lccftrack.greentownship.my/admin/users/login)

Figure 1: Forest and planted vegetation Area in UiTM Campus Shah Alam

2.2 Method

In general, four components of performance criteria were used in this study; urban environment, urban infrastructures and building are being used in the Low Carbon City Framework (LCCF) and assessment system [3]. The data compute and processed into the LCCF Track online system (http://lccftrack.greentownship.my/admin/users/login) to get the level of the Best Practices of the LCCF Diamond Rating System. Beside high carbon emission comes from campus operation, sources of carbon
also based on the consistency of data availability. The establishment of the UiTM LCCF method covers four stages as below:

i) Recognize the Key Partners & Stakeholders
ii) Establish the baseline data (data identification and availability) and boundary
iii) Develop Campus Strategy (Define Objectives and Set the Target)
iv) Implementation and review of the UiTM LCCF Boundary

3. Results and Discussion

Hence, it was used as the total area of UiTM LCCF assessment which is where the waste produced, energy consumption and water used was recorded. Based on data available, the baseline data established covers waste generation and water usage for the year 2015, while monthly energy consumption record in kilowatt-hour, kWh for the year 2015 for baseline data. The details data from the three sectors are as follow:

i. Water Sector Fluctuation in water usage recorded by 3,571206.00 m$^3$ (2015), 2,760194.00 m$^3$ (2016 and 3,073950.00m$^3$ (2017) 2, 153, 242m$^3$ (2018) meanwhile 2, 153, 242m$^3$ (2019) as in (Figure 2).

![Figure 2: Annual Water Consumption for 2015 until 2019.](image)

Whilst, there are continuous strategies have been implemented to ensure good utility of water supplies. Water utilities are some of the first to cope with the impacts of climate change leading to water scarcity, water quality and flooding challenges in campus. Indeed, also contribute to global emission from energy consumption as well as nitrous oxide and methane emission from wastewater management [11]. In UiTM, the effort was established to reduce the non-revenue water, (NRW) due to pipe breaking. Table 1 show continuous strategies are implemented to ensure good water management in campus. The water efficient appliances usage was installed to control volume of water in air-conditioning system in most building in campus. The installation of low and dual flush model for toilet and pipeline were replaced to improve water distribution in campus.
Table 1: Strategies in water utilities management in campus

| No. | Campaign, promotion and education | Verification | Number of programs | Year 2018-2020 | Faculty | Ongoing |
|-----|----------------------------------|-------------|--------------------|----------------|---------|---------|
| 51  | Water saving and conservation    | T1          | Installation of rainwater harvesting system at suitable location including buildings and open spaces within the campus | 2018-2020 | UiTM facility maintenance | Ongoing |

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|-----|----------------------------------|-------------|----------------------------|------------|-------------------------|---------|
| 52  | Energy Sector                    | T1          | Data for on-site fossil fuel consumption and grid electricity in the entire gross internal area of UiTM-owned buildings is collected from the UiTM Development Infrastructure Office [11]. Further, the energy consumption recorded at 66,482.91 kWh (2015) as a baseline year and the trend showed decreasing of consumption for following years 65,486.21 kWh (2016), 61,459.85 kWh (2017) 58,879.75 kWh (2018) and a slight increase in 2019 about 60,648.21 kWh (Figure 4). The decreasing trend of energy consumption may due to university policy of relocating high energy used equipment to another places. |

**ii. Energy Sector**: Data for on-site fossil fuel consumption and grid electricity in the entire gross internal area of UiTM-owned buildings is collected from the UiTM Development Infrastructure Office [11]. Further, the energy consumption recorded at 66,482.91 kWh (2015) as a baseline year and the trend showed decreasing of consumption for following years 65,486.21 kWh (2016), 61,459.85 kWh (2017) 58,879.75 kWh (2018) and a slight increase in 2019 about 60,648.21 kWh (Figure 4). The decreasing trend of energy consumption may due to university policy of relocating high energy used equipment to another places.

![Figure 3: Annual Electricity consumption for year 2015 until 2109](image-url)
There are implemented and undergoing strategies to ensure the energy efficiency in the campus for energy-efficient appliances usages such as LED lighting, inverter air-cond and precision air-cond with an inverter, Photovoltaic roof solar panel at particular building with a total of 20kW, Smart Building Installation of photocell sensor at Engineering Complex as in Figure 5. Nonetheless, the most cost-effective ways to save energy and reduce GHG emissions is through changing energy-consuming habits and behaviours [12]. As a higher education institution through education role, the university invests the awareness-raising campaigns addressed to the campus community. At the national level, the transformation behaviour through improving environmental awareness is critical to ensuring Malaysia’s sustainable transition to a low-carbon country, although it takes time and challenging [1]. In this case, which reward or incentives approach would also increase the attractiveness of the campus community in participating in any sustainable program.

![Figure 4: Installation of energy efficient appliances usage such as LED lighting, inverter aircond and precision aircond with inverter, photovoltaic roof solar panel](image)

iii. Waste Sector. Waste generation recorded generated about 1995.83 tCO₂/year emitted in the year 2015, 2257.482 tCO₂/year (2016), 2511.835 tCO₂/year (2017), 2601.025 tCO₂/year (2018) and 3376.861tCO₂/year (2019) (Figure 3). Figure 3 shows the increasing pattern of carbon emitted from generated waste. It has been found that the current waste management practices at in UiTM were
landfilled and small scale of reduction of solid waste through composting and recycling effort. Communities, such as academic universities and higher education institutions, produce a large quantity of waste on a daily basis [13]. A college campus has the potential to create environmental sustainability projects because of its size and influence on surrounding populations. This is causing various environmental impacts, most notably global warming [14]. Suggested by [15] the combination of 70% recycling, 29% incineration and 1% landfill could reduce global warming potential by 47% compared to the current waste management practice, and that this could be achieved at an affordable cost. The study reveals that a substantial amount of carbon from energy consumption in building contributing more but waste reductions initiative gives more percentage of overall carbon emissions reduction. As a matter of fact institute of higher education should strategize in waste management or prioritizes practices from waste prevention to the landfill since it is one of the fastest, easiest, most cost-effective short-term climate solutions, i.e., zero waste strategies are a cost-effective climate solution.

![Figure 5: Annual Waste Generation from year 2015 until 2019](image)

In line with the nation’s commitment was announced to the global community, the operational approaches to meet sustainability goals in the universities are diverse and the practices are very broad and include improved environmental performances that may not necessarily be equivalent to sustainability. Sustainability is linked with setting quantitative targets in areas such as energy use, water use, use of land, purchases of product and emissions to air, water and land and achieving sustainability in the university is a process of setting goals to determine the extent of the aspects of the university required to be sustained [16].

**Conclusion**

The paper provided an overview of UiTM carbon commitment is to reduce 45% emission intensity by 2030 from the baseline of the year 2015. A city-based approach is chosen for the whole campus with
special projects of a performance-based approach are outlined in achieving the Sustainable Development Goals (SDG) through sustainable campus initiatives, practices, green governance and ecosystem; and university-community linkages and partnerships for the goals. A carbon management plan is underway to enable UiTM to be Malaysia’s best Low Carbon Public University Model by 2030, while also striving for carbon-neutrality. Therefore, in line with both the institutional mission and the climate neutrality goal, this plan identifies actions to promote investments devoted to energy, environment and climate and to further integrate sustainability in teaching and learning. These can be progressively giving a positive result in reductions in GHG emissions, indirectly the promotion of cultural and behavioral changes will also exhilarate in achieving the climate neutrality goal.

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References

[1] Susskind L, Chun J, Goldberg S, Gordon JA, Smith G and Zaeerpoor Y, “Breaking Out of Carbon Lock-In: Malaysia’s Path to Decarbonization.” Front. Built Environment, 6:21, 2020.
[2] S. K. Juahari, D. Omar, O. L. H. Leh, S. M. Kamarudin and M. A Marzuki, “The Readiness of The Stakeholders In The Implementation Of Low Carbon Cities Framework (LCCF) In An Urban Area,” IOP Conf. Series: Earth Environ. Sci. 385 012071, 2019.
[3] Ministry of Energy, Green Technology and Water (KeTTHA), “Low Carbon Cities Framework”, 2017.
[4] A. Adaayemi “Measuring and Monitoring Carbon Emission to Promote Low-Carbon Development in Johor Bahru, “Malaysia Sustainable Cities Program, Working Paper Series, Massachusetts Institute of Technology, Pp 1-23, 2016.
[5] I. S. Zen, M. Bandi, K. D Karniah, I. N. Abu Bakar and R. Zakaria, “Assessing the Operational Carbon at University,” Proceedings, Vol. 2, 1370, 2018.
[6] L.A. Abdul-Azeez, “Development of Carbon Dioxide Emission Assessment Tool towards Promoting Sustainability in UTM Malaysia,” Open Journal of Energy Efficiency, 7, 53-73. 2018
[7] L. Velazquez, N. Munguia and M. Sanchez, “Deterring sustainability in higher education institutions: An appraisal of the factors which influence sustainability in higher education institutions”, International Journal of Sustainability in Higher Education, Vol. 6 No. 4, pp. 383-391, 2005.
[8] A. Adeyemi, and C. S. Ho “Realizing Low Carbon Emission in the University Campus towards Energy Sustainability,” Open Journal of Energy Efficiency, 4(02): 15-27, 2015.
[9] H.M. Alshuwaikhat, and I. Abubakar, “An Integrated Approach to Achieving Campus Sustainability: Assessment of the Current Campus Environmental Management Practices,” Journal of Cleaner Production, 16, Pp 1777-1785, 2008.
[10] Milad Mohammadzadehkorde and Russell Weaver, “Universities as Models of Sustainable Energy-Consuming Communities? Review of Selected Literature,” Sustainability, Vol. 10, 3250, Pp 2-17, 2018
[11] UiTM Development Infrastructure Office https://ppii.uitm.edu.my/.
[12] D. Cotton, C. Shiel, A. Paço, “Energy saving on campus: a comparison of students' attitudes and reported behaviours in the UK and Portugal,” Journal of Cleaner Production, Volume 129, Pages 586-595, 2016.
[13] S. Ballard, J. Porro, and C. Trommsdorff, “The roadmap to a low-Carbon Urban Water Utility: An international guide to the WaCClim Approach,” IWA Publishing, 2018.

[14] D. Spirovski, A. Abazi, I. Iljazi, M. Ismaili, G. Cassulo, A. Venturin, “Realization of a Low Emission University Campus Trough the Implementation of a Climate Action Plan,” *Procedia - Social and Behavioral Sciences*, Volume 46, 2012, Pp 4695-4702, 2012.

[15] R. Lukman, A. Tiwary, A. Azapagic, “Towards greening a university campus: The case of the University of Maribor, Slovenia, Resources,” *Conservation and Recycling*, Vol. 53, Issue 11, Pp. 639-644, 2009.

[16] P. F. Barlett, “Campus sustainable food projects: Critique and engagement,” *American Anthropologist*, Vol. 113(1), Pp. 101-115, 2011.