

PAPER • OPEN ACCESS

Sustainable assessment of academic buildings at Universiti Teknologi Petronas campus

To cite this article: W A Al Madhoun *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **228** 012021

View the [article online](#) for updates and enhancements.

Sustainable assessment of academic buildings at Universiti Teknologi Petronas campus

W A Al Madhoun¹, A A Firdaus¹ and H A Isiyaka²

¹Civil and Environmental Engineering Department, Universiti Teknologi Petronas, 32610 Seri Iskandar, Perak Darul Ridzuan, Malaysia.

² Department of Geography, Faculty of Earth and Environmental Sciences, Kano University of Science and Technology Wudil, Nigeria.

Abstract. The objectives of this study are; to investigate the most suitable method for Sustainable Building Assessment, to gather the data of specific indicator and validate each criteria according to sustainable building assessment benchmark. However, variables like energy efficiency, indoor environmental quality, sustainable site planning and management, available materials and resources, water efficiency and innovation were integrated and separately studied to develop a sustainable academic building environment in the campus of university Petronas, Malaysia. Sustainable assessment tools, GBI tool and in-depth literature review were used. The result shows that GBI sustainable building assessment of Universiti Teknologi Petronas scores 43 out of 64 which is 67% of the total score hence the rating would be Silver. This result proves that some improvements need to be made on some parameters, which did not pass the requirements. In a nutshell, Universiti Teknologi Petronas has high potential to meet GBI certified level that will help to increase the ranking status of the university to higher level. This also would be a great opportunity for the university to set a benchmark as a role model of green university in Malaysia. However, this study recommends that UTP management develops corrective policies to improve the building overall performance and standard.

1. Introduction

The energy used in construction, occupying and operating buildings is the major contributor to climate change that has various impacts on the environment. Therefore, constructions and building industries have the potential to recover the natural environment and community culture by conforming to the sustainable benchmarks set by the local and global requirements while enhancing the value of products and services to business, customers and society in general. To comply with these needs, there has been an increasing interest in sustainable assessments of the built environment. Recently, we can now find few number of great sustainable assessment tools regardless of new or built environment, focusing on energy use in buildings, building materials, optimized operational, conservation of water resource,



preservation of regional and cultural identity, convenient indoor climate and maintenance practices. Universities need to be sustainable in every attribute, economic, social and environment. Therefore, Sustainable Building Assessment has to be done to evaluate and find the key indicator or criteria required to measure in order to rank the university campus sustainability. By investigating different methods of assessment, this study would be able to explore the suitability and adaptability of the tools by comparing the criteria and benchmarks to Malaysia Practice. From here, the method could be implemented to assess the building sustainability of Universiti Teknologi Petronas building campus. The objectives of this study are; to investigate the most suitable method for Sustainable Building Assessment, to gather the data of specific indicator or criteria, to analyse and validate each criterion according to sustainable building assessment benchmark.

2.0 Literature Review

Buildings can be classified as sustainable when all the sustainability aspects such as environmental, economic, social and cultural are evident in the buildings. The main reasons to achieve sustainable buildings are to solve the issues and concerns regarding wastes, pollutants, non-renewable materials, water and reduction of harmful emissions. To comply with these key aspects, several methods of building sustainability assessments have been developed with same goal which is to achieve the optimisation of site potential, preservation of regional and cultural identity, minimisation of energy consumption, protection and conservation of water resources, use of environmentally friendly materials and products, a healthy and convenient indoor climate, and optimised operational and maintenance practices.

2.1 Development of Sustainable Assessment Tool

The main objective of sustainability assessment is to collect and report data for decision-making during different phases of the construction, design and use of building [1]. The development of assessment methods and respective tools are very complicated to practice and understand due to major issue of managing the flow of information and knowledge between the various level of indicator systems [1]. There are many Sustainable Building Assessment methods currently available in the market and they are widely used in the environmental product declaration. These methods have been developed worldwide and are built upon various principles and different evaluation items, data and criteria. However, a comparison of sustainable assessment tool is described in table 1.

2.2 Sustainable Assessment Tool Comparison

Table 1: Sustainable Building Rating Tool Comparison

Comparison Item	Sustainable Assessment Tools			
	BREEAM	SB TOOL	LEED	GBI
Flexibility	Moderate	High	Moderate	High
Market	Strong	Moderate	Strong	Moderate
Characteristic	Two Process	4 Phases	Industrial Standard	Tropical Climate

2.3 The Implementation of GBI Tool

The purpose of GBI is to enable green grading and certification of Malaysian buildings. GBI is a rating system providing a comprehensive framework for building assessment, which is similar to BREEAM (UK), LEED (USA), Green Star (Australia) and Green Mark (Singapore). [2] states that Malaysia's GBI focuses on indoor environmental quality, sustainable site planning and management, materials and resources, water efficiency and innovation. GBI has simplified and standardized the green building concept in Malaysia so that no misunderstanding occurs. GBI define green buildings by establishing a common language and standard of measurement. Other than that, it promotes integrated whole building

designs that provide a better environment. In addition, they recognize and reward environmental leadership and transform the built environment to reduce its negative environmental impact. Lastly, GBI ensures new buildings remain relevant in the future and existing buildings are refurbished and upgraded to non-governmental and profession driven green rating tool developed for the tropical climate [2].

3.0 Methodology

This study was carried out in Universiti Teknologi Petronas academic buildings where several data were collected from authorities of both management and technical departments in order to fulfil the data requirement for Sustainable Building Assessment. However, extensive research on previous studies was carried out to extract as much data required for the assessment purpose as possible. The techniques applied in this study include sustainable assessment tools, GBI tools and in-depth review of literature in order to have a detailed understanding of the current situation of buildings in UTP.

4.0 Result and Discussion

This result was based on GBI Assessment Criteria for Non-Residential Existing Building (NREB) 1st Edition, January 2011, Version 1.1 which was conducted on Universiti Teknologi Petronas.

4.1 Energy Efficiency

An assessment of the energy efficiency is fully described in table 2. The total score for Energy Efficiency (EE) would be 3 out of 38. This is due to the fact that certain items cannot be evaluated as mentioned as shown in the table thereby affecting the outcome of the total score for Energy Efficiency (EE). Therefore, the marks for EE5, EE6, EE7 and EE9 will be excluded from the total score. The new total score for energy efficiency will be known as maximum possible score which is 10.

Table 2: Energy efficiency utilization

Energy Efficiency (EE)		
Item	Justification	Source
EE1	Evaluation not possible due to having no opportunity on BEIT software or other GBI approved software. UTP currently using Fuzzy control management.	Zazilah, Nor, Mohd, N., Jusoff, & Kamaruzaman. (2011). Optimal Operation of Chiller. <i>Recent Researches in Artificial Intelligence, Knowledge Engineering and Data Bases</i> , 109-115.
EE2	Lighting controls are control through energy management that are automatically turn on and off according to time.	Bhaskoro, P. T., Gilani, S. I., & Aris, M. S. (2013). Simulation of energy saving potential of a centralized HVAC system in an academic building . <i>Energy Conversion and Management</i> , 617-628.
EE3	No Sub-metering due to centralized energy control.	NA
EE4	Main energy source are from UTP GDC which do not use any renewable energy source.	Khamis, M. F., Baharudin, Z., Hamid, N. H., Abdullah, M. F., & Solahuddin, S. (2011). Electricity Forecasting For Small Scale Power System Using Artificial Neural Network . <i>The 5th International Power Engineering and Optimization Conference</i> , 54-59.
EE5	Evaluation not possible due to having no opportunity on BEIT software or other GBI approved software	NA

EE6	Required GBI recognized commissioning specialist (CxS) to perform the commissioning.	NA
EE7	Required GBI recognized commissioning specialist (CxS) to perform the commissioning.	NA
EE8	Currently using energy management system to log building system performance for HVAC system efficiency.	Khamis, M., Baharudin, Z., Hamid, N. H., Abdullah, M. F., & Nordin, F. T. (2011). Short Term Load Forecasting for Small Scale Power System Using Fuzzy Logic. <i>IEEE</i> , 1-5.
EE9	Non-available resource.	NA

4.2 Indoor Environmental Quality

Detail on indoor environmental quality is described in table 3. Hence the total score for Indoor Environmental Quality (EQ) would be 17 out of 21. This is due to deduction of points on low thermal comfort control, high glare and high noise level based on the IEQ and POE assessment.

Table 3: *Indoor Environmental Quality*

Indoor Environmental Quality (EQ)		
Item	Justification	Source
EQ1	Minimum indoor air quality (IAQ) performance meet the minimum requirements of ventilation rate and are contributing to the comfort and well-being of the occupants.	Khamidi, m. F., ismail, s. N., & mohd, n. (2013). Post occupancy evaluation (poe) and indoor environmental quality (ieq) assessment. <i>Journal design + built</i> , 1-21
EQ2	Prohibited smoking in all university area.	UTP management and policy.
EQ3	CO ₂ monitoring had been done and meet minimum outside air requirement to maintain CO ₂ level < 1,000 ppm	Khamidi, m. F., ismail, s. N., & mohd, n. (2013). Post occupancy evaluation (poe) and indoor environmental quality (ieq) assessment. <i>Journal design + built</i> , 1-21
EQ4	Using low VOC paints and coatings throughout the building and no added urea formaldehyde.	Kara, H. (2007). <i>University of Technology Petronas</i> . Bandar Seri Iskandar
EQ5	The building is fully naturally ventilated. Rainwater leakage through roof and walls.	Kara, H. (2007). <i>University of Technology Petronas</i> . Bandar Seri Iskandar
EQ6	No individual control on thermal comfort system.	Khamidi, M. F., Ismail, S. N., & Mohd, N. (2013). Post Occupancy Evaluation and Indoor Environmental Quality Assessment. <i>Journal Design + Built</i> , 1-21.
EQ7	The air change effectiveness meets the criteria. There are two types of mechanical ventilation system: variable volume constant	Khamidi, M. F., Ismail, S. N., & Mohd, N. (2013). Post Occupancy Evaluation and

	temperature air-conditioning, and 100 per cent fresh air constant volume variable temperature air handling.	Indoor Environmental Quality Assessment. <i>Journal Design + Built</i> , 1-21.
EQ8	>50% of the NLA has a daylight factor in the range of 1.0-3.5% as measured at the working plane.	Khamidi, M. F., Ismail, S. N., & Mohd, N. (2013). Post Occupancy Evaluation and Indoor Environmental Quality Assessment. <i>Journal Design + Built</i> , 1-21.
EQ9	94% of respondents claim that there is too much glare from artificial light. The assessments verify the result of POE.	Khamidi, M. F., Ismail, S. N., & Mohd, N. (2013). Post Occupancy Evaluation and Indoor Environmental Quality Assessment. <i>Journal Design + Built</i> , 1-21.
EQ10	According to MS1525, lighting for working interior for general offices is between 300-400 lux, while for class room 300-500 lux. However, the readings taken shows the illumination levels exceed the recommended value. This is most probably due to the exposure of the room towards the natural light (sunlight).	Khamidi, M. F., Ismail, S. N., & Mohd, N. (2013). Post Occupancy Evaluation and Indoor Environmental Quality Assessment. <i>Journal Design + Built</i> , 1-21.
EQ11	Different types of lighting are used: Laboratories: Surface-mounted fluorescent luminaries with low-brightness louvres Double-height Areas: High-bar luminaries Toilets /corridors: Low-voltage down lighters Library bookshelf: Linear fluorescent luminaries with low brightness louvers Lecture theatre: Low-voltage down lighters and wall-mounted floor washers Cafeterias: Modular fluorescent luminaries	Kara, H. (2007). <i>University of Technology Petronas</i> . Bandar Seri Iskandar
EQ12	>75% of the NLA has a direct line of sight through vision glazing at a height of 1.2m from floor level	Khamidi, M. F., Ismail, S. N., & Mohd, N. (2013). Post Occupancy Evaluation and Indoor Environmental Quality Assessment. <i>Journal Design + Built</i> , 1-21.
EQ13	For the lecture room, lab and lecturer room, the distraction comes from the blowers of air cons that produce high level of noise. The contribution of outdoor noise to indoor noise levels is usually small.	Khamidi, M. F., Ismail, S. N., & Mohd, N. (2013). Post Occupancy Evaluation and Indoor Environmental Quality Assessment. <i>Journal Design + Built</i> , 1-21.
EQ14	Reading for average temperature, relative humidity, CO ₂ level and air velocity indicates that each element will contribute 1 point for GBI rating scores.	Khamidi, M. F., Ismail, S. N., & Mohd, N. (2013). Post Occupancy Evaluation and Indoor Environmental Quality Assessment. <i>Journal Design + Built</i> , 1-21.

EQ15	According to POE result, two parameters which are temperature and noise did not pass severity index boundary, means the most unsatisfied parameter.	Khamidi, M. F., Ismail, S. N., & Mohd, N. (2013). Post Occupancy Evaluation and Indoor Environmental Quality Assessment. <i>Journal Design + Built</i> , 1-21.
------	---	--

4.3 Sustainable Site Planning and Management

Based on these evaluated parameters, Sustainable Site Planning and Management (SM) score would be 7 out of 10 total score. UTP lost few marks due to lack acknowledgement on green vehicle priority and building user manual. Preferred car park should be provided for low-emitting and fuel-efficient vehicles. Also, UTP management needs to update building user manual as a guide and strategies for user information to sustain the building performance. This is described in table 4 below.

Table 4: Sustainable Site Planning and Management

Sustainable Site Planning and Management (SM)		
Item	Sustainable Site Planning and Management Justification	Source
SM1	The academic buildings have not been rated by any GBI or green rating system.	UTP
SM2	The building exterior are maintained by using environmentally nonpolluting chemical.	UTP
SM3	Erosion and sedimentation control for ongoing landscape operations including erosion and sedimentation are strictly monitored.	UTP
SM4	UTP does promote use of green vehicle however parking lots for green car is not provided.	UTP
SM5	UTP are providing parking for carpools and bus stop at every village, in front of Chancellor hall and main entrance.	Kara, H. (2007). <i>University of Technology Petronas</i> . Bandar Seri Iskandar
SM6	The roof design responds intelligently to the local climate by controlling the strong solar radiation and equally heavy downpours. Glazing is 10-millimeter single clear float glass with horizontal external shading to reduce solar transmission – a choice partly made possible by the protecting roof gesture.	Kara, H. (2007). <i>University of Technology Petronas</i> . Bandar Seri Iskandar
SM7	Currently, there is no documentation of green building design features and strategies for user information and guide to sustain performance during occupancy.	UTP management

4.4 Materials and Resources

The score for Materials and Resources (MR) is 5 out of 9 total score. However, MR1, MR2, MR3 parameters will be excluded. Therefore, it will be 5 out of 6 maximum possible scores. This is described in table 5.

Table 5: Materials and Resources

Items	Justification	Source
MR1	Non-available information	Na
MR2	Non-available information	Na

MR3	Non-available information	Kara, H. (2007). University technology Petronas. Badar Seri Iskandar
MR4		Na
MR5	Recycling bins are provided and UTP does not encourage minimization and recycling among occupants	UTP
MR6	The refrigerants are non-CFC or HCFC because the cooling system are from GDC chilled water.	Kara, H. (2007). University technology Petronas. Badar Seri Iskandar

4.5 Water Efficiency

Table 6 explains the water efficiency and availability. The total score for Water Efficiency (WE) is 6 from total of 12. However, WE4 and WE5 parameters with total score of 5 are excluded due to non-available data. Therefore, the score for Water Efficiency (WE) is 6 out of 7 maximum possible score.

Table 6: Water Efficiency

Water Efficiency (WE)		
Item	Justification	Source
WE1	Water is collected from the roof to be used for irrigation.	Kara, H. (2007). <i>University of Technology Petronas</i> . Bandar Seri Iskandar
WE2	Wastewater are being treated so that it can be recycled. Example are boiler water, cooling water and chilled water.	Kara, H. (2007). <i>University of Technology Petronas</i> . Bandar Seri Iskandar. Shahar, N. A. (2016, August 19). <i>GDC UTP</i>
WE3	Potable water consumption for irrigation are used from collected rainwater.	Kara, H. (2007). <i>University of Technology Petronas</i> . Bandar Seri Iskandar
WE4	No reference to utility calculations and water consumption record.	NA
WE5	No data available	NA

4.6 Innovation

Finally, for Innovation (IN), the score evaluated is 5 out of 10 total score. To summarize, all the scores obtained is compared in the table to give a clearer view of current sustainability status of the academic building at Universiti Teknologi Petronas. To improve IN score, UTP should implement advanced air filtration technology, waterless urinals to be fitted to all male toilets. Central vacuum system that serves at least 50% of NLA also should be installed. Apart from that, fire system water during regular testing

should be recycled and the use of self-cleaning facade and electro chromic glazed facade could help increase the innovation point.

Table 7: Innovation Introduced

Innovation (IN)		
Item	Justification	Source
IN1	UTP are currently using Co-generation system. Thermal mass storage system also accounting for at least 25% of total required capacity. Low ventilation system also available to reduce energy consumption.	Ambri, Z., & Yongo, W. (2011). Analytical Models for Energy Eudit of Cogeneration Plant. <i>Journal of Applied Sciences</i> Zahid, M., Ghazali, Z., & Rahman, H. U. (2017). A Step towards Sustainable University: A Case of Universiti Teknologi PETRONAS (UTP) Malaysia. <i>Global Business and Management Research: An International Journal</i> , 492-504
IN2	No engagement services of a Green Building Index in UTP at the time of this assessment.	UTP

5.0 Conclusion

Based on the results of GBI sustainable building assessment, Universiti Teknologi Petronas scores 43 out of 64 which is at 67% of total score hence the rating would be Silver. This result proves that some improvements need to be done on some parameters which did not passed the requirements. In a nutshell, Universiti Teknologi Petronas has high potential to meet GBI certified level that will help to increase the ranking status of university to higher level. This also would be a great opportunity for the university to set a benchmark as a role model of green university in Malaysia. However, this study recommends that UTP management develops corrective policies to improve the building overall performance and standard.

6.0 References

- [1] Bragança L, Mateus R and Koukkari H 2010 Building Sustainability Assessment Sustainability 2010-2023
- [2] Khamidi M F, Ismail S N and Mohd N 2013 Post Occupancy Evaluation and Indoor Environmental Quality Assessment Journal Design and Built 1-21
- [3] Kara H 2007 University of Technology Petronas Bandar Seri Iskandar
- [4] Ambri Z and Yongo W 2011 Analytical Models for Energy Eudit of Cogeneration Plant Journal of Applied Sciences
- [5] Zazilah N, Mohd N and Kamaruzaman J 2011 Optimal Operation of Chiller. Recent Researches in Artificial Intelligence, Knowledge Engineering and Data Bases, 109-115
- [6] Khamis M, Baharudin Z, Hamid N H, Abdullah M F and Nordin F T 2011 Short Term Load Forecasting for Small Scale Power System Using Fuzzy Logic IEEE 1-5
- [7] Bhaskoro P T, Gilani S I. and Aris M S 2013 Simulation of energy saving potential of a centralized HVAC system in an academic building Energy Conversion and Management 617-628

- [8] Bhaskoro P T, Gilani S I and Aris M S 2011 Electricity Forecasting for Small Scale Power System Using Artificial Neural Network The 5th International Power Engineering and Optimization Conference 54-59
- [9] Shahar N A 2016 GDC UTP <https://prezi.com/hx5rcaizg3gp/gdc-utp-by-nuraqilah/?webgl=0>
- [10] Okitsu J, Fatimie M, Zakaria N, Noano K and Abba A 2013 Towards an Architecture for Integrated Gas District Cooling with Data Center Control to Reduce CO₂ Emission IEEE
- [11] Zahid M, Ghazali Z, and Rahman H U 2017 A Step towards Sustainable University: A Case of Universiti Teknologi PETRONAS (UTP) Malaysia Global Business and Management Research: An International Journal 492-504
- [12] Yahya S S, Ariffin A and Ismail M 2009 Green Buildings in Campus: An Assessment of Green Potential for Existing Conventional Building Urban and Conservation Tropical Architecture Centre 1-17
- [13] Long M 2016 Benefits of Green Building <https://www.usgbc.org/articles/green-building-facts>
- [14] Administration U E 2017 U.S. Energy-Related Carbon Dioxide Emissions Washington: Independent Statistics and Analysis