The energy audit process for universities accommodation in Malaysia: a preliminary study

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Abstract. The increase of energy consumption in the Malaysian Universities has raised national concerns due to the fact that its consumption increase government fiscal budget and at the same time contributes negative impacts towards the environment. The purpose of this research is to focus on the process of energy audit conducted in the Malaysian universities and to identify the significant practice that can improve energy consumption of the selected universities. The significant criteria in energy audit may be found by comparing the energy implementation process of selected Malaysian universities through the investigation of energy consumption behavior and the number of electrical appliances, equipment, machinery and buildings activities that have an impact on energy consumption that can improve energy-efficiency in building. The Energy Efficiency Index (EEI) will be used as an indicator and combined with the suggested application of HOMER software to obtain solution and possible improvement of energy consumption during energy audit implementation. A document analysis approach will also be obtained in order to identify the best practice through the selected energy documentations. The result of this research may be used as a guideline for other universities that consume high energy in order to help improving the implementation of energy audit process in their universities.

Keywords – energy audit & universities accommodation

1. Introduction
The increase of private and government universities has a great impact on educational development for the bright national future but the problem is it also increases the energy demand. The major concern is most of the universities use high energy consumption and will impose a huge cost burden on universities. Recognizing that the development should be conducted in parallel with building sustainability, various methods and policies should be introduce in order to help the building performance in achieving energy efficiency. To motivate sustainable building practice and guidance to manage energy efficiently, a few codes related to energy policy have been introduced, for instance The Malaysian Standard MS1525:2014, Code of Practice on Energy Efficiency (EE) and Use of Renewable Energy for Non-Residential Building (Department of Standard Malaysia, 2014), Energy Efficiency and Conservation Guidelines [1], ISO 50001: Energy Management System [2] and Uniform Building By Law (UBBL). In 2008, the Efficient Management of Electrical Energy Regulation 2008 [3] also has been introduced. It stated that any installation which receives electrical energy from a supply authority with a total electricity consumption equal to or exceeding 3,000,000 kWh as measured at one metering point over any period of six consecutive months must comply with
requirements in the regulations. For the development of electrical energy efficient, the organization must conduct an energy audit as a first step. Since Malaysian utility company, Tenaga Nasional Berhad (TNB) has raised the electricity tariffs in 2015 [4], the biggest concerns for many universities is it will affect the universities energy expenditure. Therefore, energy audit is essential in order to increase saving and improve energy efficiency. A building sector should invest in new energy efficient technologies to optimize the energy use [5]. Malaysia’s energy consumption increases every year. In 2008, the total energy demand was 522,199 GWh, where the industrial and transport sectors were the largest consumer around 3/4 of total demand [6]. The residential and commercial sector was the third largest consumer (14%) and only 1% consumed by the agriculture sector [7]. The energy consumption in Malaysia rises rapidly in Malaysia every year, with an average of 2,533 GWh per year [6] which involves universities as major energy users. University buildings consume high energy in the classification of commercial buildings due to its activities and populations [8]. Despite the recommendations by The Malaysian Ministry of Education (MOE) and The Malaysian Ministry of Higher Education (MOHE) to all educational institutions to undertake the responsibility to save energy; which was in line with the efforts to implement energy saving programs in government buildings [9], there are still huge energy wastage in this sector. Unnecessary energy wastage may occur due to lack of awareness on the importance of energy saving building user. This is where energy audit is significant. Energy audit can be defined as the analysis of energy flows in buildings, systems, processes or equipment to reduce the amount of energy input into the system without negatively affecting the energy output [10]. Energy audit is conducted to comprehend the buildings energy performance and facilities so the potential for improvements will be found [11]. The Malaysia Ministry of Education has insist all education centers to lessen energy consumption due to the expensive monthly commitment of electricity bill that become the major concerns of all parties [12]. The government has encouraged consumers to practices on energy saving activities such as switching off all electrical equipment when not in use [13]. Energy wastage in Malaysian university mainly cause by inefficient energy use and lack of awareness among the users, therefore it is importance to raise awareness among consumers [14]. Without awareness, there will be a difficulties to sustain an energy efficiency. Energy efficiency strategy may reduce running energy costs that is related with the life of the buildings [15]. Improving energy efficiency will produce better building with comfortable working environment, more satisfaction and improved productivity [15]. This is in line with the attempt by the Ministry of Energy, Green Technology and Water (2009) to begin energy saving programs in all government departments. There are multiple reasons why implementing energy audit and improving energy consumption in local university is important. Universities have a large number of building users and large number of facilities compared to other industries. The typical energy bill in education sector is approximately 5% of the total expenditure of the university [16]. There is a possibility of saving 5-10% of the energy expenditure by implementing improve energy-use behaviour [17]. Lack of awareness and failure to fully implement the highly energy efficient technologies during design stage has result the high energy consumption. In overall, the University had to bear a high fiscal cost in order to run the university. Without effective energy audit, the total energy consumption will increase and also effect the cost. At the moment, the energy audit implementation in Malaysian universities is still lacking. Most of the universities, fail to implement proper energy audit. For the success of energy audit implementation, energy efficient awareness is necessary and commitment of top management and involvement of entire stuff in organization is a must [18]. Thus, energy audit in the building sector should be recognize as a comprehensive approach in order to gain more energy efficient. From statistics released by the Ministry of Higher Education (2016), there are 21 public universities, 71 private universities and six foreign universities branch campuses in Malaysia. According to the Planning and Research Unit (2011), there are 937,231 students enrolled in Malaysian higher education institutions. This indicates that the number of accommodation facilities for students also plays an
important role in universities [19]. It can be considered that student are the largest consumers of energy in universities [20]. Therefore the implementation of energy audit in residential colleges is expected to be very significant in reducing overall energy consumption. Even though energy use in residential college is usually 10 to 20 times lower compared to office buildings, the average energy consumption of non-air-conditioned residential colleges in tropical regions is in the range between 20 to 60 kWh/m²/year [21]. This data shows that the energy usage in student accommodation is significant towards the increase of electricity use in university. Due to this, this research will focus on how energy audit can be implemented towards achieving more energy efficient usage.

2. Literature review
The development of higher education institutions is in line with the development of Malaysia to meet the needs of local and abroad students. Sustainable development is a development that meets the requirement of current situation without affect the future generations need [22]. The sustainability concept is widely known in different sectors such as government, private and also in education sector [23]. In order to achieve this sustainability, energy audit is important for all buildings. The objective of an energy audit is to regulate where, when, why and how energy is used in the buildings and to identify opportunities to improve. Energy audits is a systematic inspection of existing energy systems to reduce overall energy inputs to the systems without negatively impact on the output of the systems [10]. An energy audit is developing a compassionate of the specific energy-using patterns of a particular facility [24]. Energy audits are implemented to identify the areas with potential energy saving and understand the energy performance of the buildings [25]. Energy audits are basically classified as preliminary walk-through and comprehensive audits, each differentiated by the detail included and the depth of analysis done [18].

1. Energy audit process
The appraisal of energy consumption patterns and recognition of energy saving measures are the most vital part of energy management activities, which can be reached via energy audits [15]. Generally, there are four levels of analysis of energy audits suggested by ASHRAE (2004).

(1.1) Level 0 – Benchmarking: analysis of the existing annual utility bill and consumption, then compare the performance of the building with similar building for benchmarking.
(1.2) Level I – Walkthrough audit: preliminary audit to evaluate building energy efficiency and energy conservation. This research is based on visual verification, installed equipment and detailed recorded energy consumption collected during benchmarking process.
(1.3) Level II – Energy survey and analysis: More detailed analysis on building performance by conducting field measurements using tools and devices.
(1.4) Level III – Detailed energy audit analysis: By referring results of pre-audit, this audit is more comprehensive on analysis of energy consumption. Using software to identify the possible improvement of energy consumption.

National Energy Policy was formulated to achieve cost-effective supply of energy and efficient utilization of energy [26]. Malaysian universities should be aware on this policy and implement energy management system however there is a missing link in the energy management process since they still consume high energy annually. Thus, the question arise on how well Malaysian universities apply an effective energy audit? The argument is the management may be focusing more on energy planning and implementation phase but lack on energy checking phase. Therefore, this research aims to explore and improve this whole energy process for the universities.
3. Research objectives

Below are the research objectives:

1. To identify the energy consumption level in universities accommodation is being used based on the actual load profile.
2. To identify the current practice of energy audit in Malaysian universities’ accommodation.
3. To determine the best practice of energy audit in achieving energy efficiency for Malaysian universities’ accommodation.

4. Research questions

Below are the Research Questions:

1. What is the level of energy consumption used in Malaysian universities accommodation?
2. How is the current practice of energy audit in Malaysian universities’ accommodation?
3. A Malaysian universities use best practice in energy audit in order to improve energy efficiency?

5. Problem statement

Public universities in Malaysia are being challenge with wastage of energy due to the lack of awareness between students and staff, and no particular guidelines for facilities to improve the situation. Lack of energy audits and minimal in-depth monitoring in universities also lead to higher energy consumption. Without proper energy audit, universities are unaware of the energy wastage situation [27]. There are correlation between poor energy audit and the increase of energy wastage among the people. Therefore, it is significant for this study to distinguish energy audit process that can leads towards energy efficiency in the universities. It is wise to highlight that “with ineffective energy audit for universities accommodation, Malaysian universities will faced inefficient used of energy which hindered the energy efficiency process”.

6. Gap

There are numerous research of energy audit on multi-residential buildings, especially in tropical regions [28]. However, there are limited numbers of research focus on energy audit for student accommodation in universities. The reason might be due to difficulty to access the level of energy use by the student. It is because that are many students in universities that use energy on a different period of time [21].

7. Research methodology
For research methodology, mixed method approaches will been used based on guideline proposed by Krarti [29] in his book “Energy Audit of Building Systems” Based on Krarti, energy audit can be divided by two types: a walkthrough audit that include a simple study by viewing on the major systems and equipment, and a detailed audit, which require a comprehensive and time consuming. Therefore, this research methodology will be divided into several stages. This method consists of 4 main phases which are:

1. **Phase I**: Data Collection
2. **Phase II**: Data Analysis
3. **Phase III**: Result and Finding
4. **Phase IV**: Reliability of Validity Data

The approach used in this research began by collecting secondary data from various sources. Secondary data includes information from books, previous research (articles and journals), websites, energy consumption data and information, the agencies involved in building conservation and other information sources.

1.1 **Sequential mixed-method approaches techniques**

The approach used in this research began by collecting secondary data from various sources. Secondary data includes information from books, previous research (articles and journals), websites, energy consumption data and information, the agencies involved in building conservation and other information sources.

**Phase 1 : Data collection**

A walkthrough survey will be carried out to survey equipment use (the type, power & consumption). Energy consumption collection of buildings will be done with data logger and ammeter. An observation on yearly electrical bills will be carried out and the use of EEI formula in order to calculate the building energy index. The last part is a research survey (Questionnaire) and the respondents will be the person in charge and the building users in order to understand method or practices on energy audit and the pattern of electricity consumption. Lastly, to analyze the energy standard use by the selected university and to study the significant energy audit in the report.

**Phase 2 : Data analysis**

This phase is to evaluate the characteristics of the pattern of energy systems in the buildings by using HOMER software to produce load profile and energy usage pattern. HOMER (Hybrid Optimization Model for Electric Renewables), developed by NREL (National Renewable Energy Laboratory, USA) as preferred tools due to several application on literature review. This software will assist on energy management during preliminary audit. The Energy Efficiency Index (EEI) being used in this research to demonstrate the performance of electric consumption at residential colleges in the unit of kWh/m²/year [30]. Energy Efficiency Index (EEI) is an evaluating method from Saidur [31], who estimated energy intensity, EEI, in kWh/m² by using following equation:

\[
EEI = \frac{\text{Energy Consumption/Input}}{\text{Gross Floor Area (m}^2\text{)}}
\]

Basically, the energy use per unit floor area can be described as “Normalised Performance Indicators” (NPI), also known as Energy Efficiency Index (EEI) or Building Energy Index (BEI) [32]. It basically calculates the ratio of total energy used against the total built-up area to calculate building yearly consumption. The energy consumption in buildings normally in
term of Energy Efficiency Index [33]. According to MS 1525 standard, recommended energy efficiency index in Malaysia is 135kWh/m²/year. The saving targets are based on the lowest EEI. A documentation analysis will also be obtained in checking related energy documents in the organizations. SPSS software also will be used for statistical analysis of questionnaire done. Identify best practice of energy audit implementation at universities by comparing energy audit reports.

**Phase 3 : Result and finding**

After completed both phase 1 and phase 2, there will be an outcome of a most significant procedure and practice in energy audit.

**Phase 4 : Reliability of validity data**

The reliability of validity data will be depend on energy audit manager expertise input, data and report of energy audit for the selected universities.

8. **Selected case study**

There are 21 public universities in Malaysia [34], whilst University Technology Mara (UiTM) comprises highest students’ population. UiTM consists total of 168,000 students’ enrollment with ⅛ of the national population. University Technology Mara is Malaysia’s largest institution of higher education in terms of size and population. Apart from the main campus in Shah Alam, the university has expanded nationwide with 13 state campuses and 24 state satellite campuses. Efficient Management of Electrical Energy Regulation 2008 (EMEER) [35] has been introduced in 2008 stated any installation which a total electricity consumption equal to or exceeding 3,000,000 kWh as measured at one metering point six consecutive months must comply with requirements in the regulations.

It requires a building owner to appoint a Registered Electrical Energy Manager (REEM) to audit and analyse the total electrical energy consumption in the buildings. As reference in Suruhanjaya Tenaga there are 16 universities in Malaysia that fall under this regulation (EMEER) [35]. For this research, three (3) UiTM’s branches have been chosen as the case study, which are UiTM Tapah, UiTM Pasir Gudang and UiTM Sg. Buloh. The aims of this research are to evaluate the efficiency of electricity consumption through an energy audit for residential accommodations. All of these residential colleges are not non-air-conditioned and provided with a ceiling fan and a fluorescent lamp.

9. **Scope and limitation**

There are many research has been done on commercial buildings but limited research on students accommodation. The scope of work for the implementation of energy audit are as per below:

1. To concentrate and study on energy pattern of the buildings
2. To identify and understand any energy saving opportunities that can be implemented
3. The thesis focuses on residential college only as a target building for energy improvement

The limitation in this research are as per below:

- The results and findings will be focus on the significant and best practices of energy audit in Malaysian universities and limited by the perceptions of recognized experts in energy audit.

10. **Significant of the study**

As recommended by the government, public and private universities should improve their energy efficiency in order to reduce the cost of university’s operational. This research can be used as an important guidance and provide useful information for residential colleges in Malaysia particularly on
current energy consumption and potential of energy saving improvement through the best practice of energy audit that has been identified through the research.

11. References

[1] Suruhanjaya Tenaga Malaysia, "Efficient Management of Electrical Energy Regulations," p. 19, 2008.
[2] International Organization for Standardization, "Energy Management System," p. 52, 2011.
[3] S. Tenaga, “Efficient Management of Electrical Energy Regulation 2008,” Effic. Manag. Electr. Energy Regul. 2008, pp. 1–30, 2008.
[4] T. Star, "The Star Online," The Star, Petaling Jaya, 2015.
[5] V. Galis and P. Gyberg, “Energy behaviour as a collectif,” Energy Effic., vol. 4, no. 2, pp. 303–319, May 2011.
[6] C. Teh, "Extraordinary mind discuss ideas," 1 July 2016. [Online]. Available: http://www.christopherteh.com/blog/2010/09/electricity-demand/.
[7] KeTTHA, 26 June 2016. [Online]. Available: http://www.kettha.gov.my/portal/index.php.
[8] M. Z. Abd-Razak, N. K. F. Mustafa, A. I. Che-Ani, N. A. G. Abdullah, and M. F. I. Mohd-Nor, “Campus sustainability: Student’s perception on campus physical development planning in Malaysia,” Procedia Eng., vol. 20, pp. 230–237, 2011.
[9] S. Ahmad, Y. H. Mohammad, A. Hayati, H. Rahman and M. Majida, "Energy Efficiency Measurements in a Malaysia," in IEEE International Conference on Power and Energy, Kota Kinabalu Sabah, Malaysia, 2012.
[10] M. B. Raghav, M. S. Srija, G. S. Rao, K. N. Bhavya, and Y. Suchitra, “ENERGY CONSERVATION AND AUDIT - A CASE STUDY,” Int. J. Adv. Res. Electr. Electron. Instrum. Energy, vol. 2013, 1970.
[11] J. E. Piper, Operations and maintenance manual for energy, New York: Sharpe Professional, 1999.
[12] V. Galis and P. Gyberg, “Energy behaviour as a collectif,” Energy Effic., vol. 4, no. 2, pp. 303–319, May 2011.
[13] KeTTHA, 26 June 2016. [Online]. Available: http://www.kettha.gov.my/portal/index.php.
[14] Wong, "Energy Conservation and Human Behaviors: The Professional Faculties Building," in University of Calgary, Calgary, 1997.
[15] M. Haji-Sapar and S. E. Lee, “Establishment of energy management tools for facilities managers in the tropical region," Facilities, vol. 23, pp. 416–425, 2005.
[16] G. Keeffe and B. Grimshaw, "Energy Management," Managing Educational Property: A Handbook for Schools, Colleges and Universities, pp. 196-209, 1994.
[17] A. Loozen and C. D. Moosdijk, "A Consumer Advise on Energy Efficient Use and," Energy Efficiency in Household Appliances and Lighting, pp. 468-474, 2001.
[18] S. R. Bhawarkar and S. Y. Kamdi, “Electrical energy audit of a electroplating unit - A case study,” 2011 Int. Conf. Recent Adv. Electr. Electron. Control Eng. IConRAEeCE’11 - Proc., pp. 25–29, 2011.
[19] C. Daniel, N. Barron, G. President, D. B. President, and P. S. Association, “the Educational Attributes of Some of the World ’ S ‘ Top 50 ’ Universities – a Discussion Paper,” no. May, pp. 1–140, 2008.
[20] J. P. Meriac, D. J. Woehr, and C. Banister, “Generational Differences in Work Ethic: An Examination of Measurement Equivalence Across Three Cohorts,” J. Bus. Psychol., vol. 25, no. 2, pp. 315–324, Jun. 2010.
[21] A. A. Jamaludin, N. Z. Mahmood, N. Keumala, A. R. M. Ariffin, and H. Hussein, “Energy audit and prospective energy conservation: Studies at residential college buildings in a tropical region,” Facilities, vol. 31, pp. 158–173, 2013.
[22] G. H. Brundtland, “Our Common Future: Report of the World Commission on Environment and Development,” Med. Conf. Surviv., vol. 4, no. 1, p. 300, 1987

T. Prugh, ”The Local Politics of Global Sustainability,” p. 196, 2000

[24] S. A. Roosa, Sustainable development handbook. Fairmont Press, 2008.

[25] Jayamaha, Energy Efficiency Building Systems, New York: McGraw-Hill, 2006.

[26] Economic Planning Unit, 26 June 2016. [Online]. Available: http://www.epu.gov.my/en/tenaga.

[27] W. W. Choong, A. H. bin Mohammed, and B. Alias, “Energy Conservation Model for Malaysian Higher Learning Institution,” 2010.

[28] Wong, "Energy Conservation and Human Behaviors: The Professional Faculties Building,” in University of Calgary, Calgary, 1997.

[29] Krarti, M. (2011). ENERGY AUDIT OF BUILDING SYSTEMS. Taylor & Francis Group (Vol. 2). http://doi.org/10.1017/CBO9781107415324.004

[30] B. S. K. Chou, “Performance-based Standards for Energy Efficient Buildings Introduction-Situation and Observations,” no. February, 2004

[31] R. Saidur, H. H. Masjuki, and M. Y. Jamaluddin, “An application of energy and exergy analysis in residential sector of Malaysia,” Energy Policy, vol. 35, no. 2, pp. 1050–1063, Feb. 2007

[32] Kamaruzzaman and Edwards, "Evaluating performance characteristics of electricity use of British historic building in Malaysia," in Facilities Vol. 24 Nos 3/4, 2006, pp. pp. 141-52

[33] M. B. A. Aziz, Z. M. Zain, S. R. M. S. Baki, and R. A. Hadi, “Air-conditioning energy consumption of an education building and it’s building energy index: A case study in engineering complex, UiTM Shah Alam, Selangor,” Proc. - 2012 IEEE Control Syst. Grad. Res. Colloquium, ICSGRC 2012, no. Icsgrc, pp. 175–180, 2012.

[34] Ministry of Higher Education, "Ministry of Higher Education," 16 June 2016. [Online]. Available: https://www.mohe.gov.my/en/ruuturun/awam/statistik/2014

[35] Suruhanjaya Tenaga & Pusat Tenaga Malaysia 2007 for Energy Efficiency and Conservation Guidelines

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