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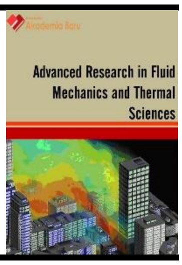

Energy Efficiency of Chancellery Building at Universiti Utara Malaysia

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ABSTRACT

There are various initiatives in ensuring the optimum and efficiency usage of energy in the government owned buildings. By complying with the MS1525:2007 standard, the energy efficiency of buildings is taken as a reference to ensure the buildings meets the current standard. This paper presents a three years' energy consumption data of the Chancellery building at Universiti Utara Malaysia. This study aims to ensure that the building is able to meet the standard requirements of the Building Energy Index (BEI). Based on MS 1525:2007 any building which implements energy efficient measures can achieve the BEI of 136kWh/m^2/year. Preliminary audit conducted involves a brief review of utility and building operation, observation and a walkthrough in the building. General audit has been conducted in order to get a better understanding of major energy consumption and to collect more detailed information about the operation of the building. Data from monthly energy usage and gross floor area of the building has been collected and the BEI was calculated. Recommendation on how to improve energy saving and enhancement for building performance are presented. Several energy efficiency practices that do not involve higher operation cost or without any additional cost are also introduced. By implementing some of the good energy efficiency measures in the building enable better assessment and continuous monitoring of energy usages within the university campus.

Keywords:
Building energy index; building energy efficiency; energy audit; energy management

1. Introduction

The operational cost and budgeting have become a concern to the management of Universiti Utara Malaysia (UUM). Having a very large campus and with mix buildings across the campus, and many older buildings and facilities in need of upgrades, is a challenge to work within a tight budget. Hence, effort was made to prevent the financial bursting in the annual operating budget. In addition to other operating expenses, energy makes up a significant percentage of UUM operating budget in which annually the electricity bill amounting around RM22 million. If savings can be made at a rate

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of 10 percent, then about RM2 million will be available for other development programs, accommodate student activities or other initiatives that benefit the entire campus community.

A major hindrance to effective energy management has been simply to identify and address problems that are costing the most money. Today, data and analytics play a dominant role in energy management. Technology helps the management detect how energy is misspent, whether from equipment in need of tune-up or repair, or "operator errors" such as some lights left turned on or thermostats set incorrectly after hours. Thus, an energy audit is the key to understanding and developing the energy management program within the university campus. Every audit typically involves data collection; plant/building surveys and system measurements; observation and review of operating practices; and data analysis before recommending an appropriate energy saving strategies.

In general, many ordinary energy saving methods require huge amount of money in implementation and management. This report presents the finding and analyses energy consumption and recommend the low-cost and/or no-cost measures to achieve energy efficiency that can be implemented on the Chancellery building. These measures are without allocating large budgets but still able to achieve energy savings with significant results.

2. Energy Efficiency

Energy efficiency is defined as a way of managing and sustaining the growth in energy consumption [1]. Any application is more energy efficient if it delivers more services for the same energy input, or the same services for less energy input [2]. Gillingham *et al.,* [3] described energy efficiency as the energy services provided per unit of energy input into the production of desired energy services such as heating and lighting.

Buildings consumed up to 40% of the total global energy, and based on current trends by the year 2030, the consumption is expected to increase to at least 50%. Buildings consume a total of 48% of the electricity generated in Malaysia. Commercial buildings such as office buildings and retails consume up to 38,645 Gigawatt Hours (GWH) while residential buildings consume 24,709 GWH. The rate of electricity consumption in Malaysia is one of the highest among emerging countries, and the increasing energy consumption is due to rapid economic growth, particularly in the residential and commercial sectors which are expending about half of the total electricity generated [4].

Typically, weather in Malaysia as in other Southeast Asian countries, which have a hot and humid tropical climate, conventional office buildings consumed more than half of energy usage in electricity, mainly for air-conditioning. Figure 1 below shows that electricity distribution in Malaysian office buildings consist of air-conditioning load with the highest percentage (58%), lighting (20%), office equipment (19%) and others (3%).

Many existing buildings was constructed with conventional designs, thus contributing to inefficient energy consumption and negative impact on the total energy performance throughout the operation stage of the buildings [6-10]. Hence, such construction not only involves inefficient energy consumption in the buildings but also by the characteristic of the buildings, i.e. not environmentally friendly and poor energy-efficient elements.

The rising demand for energy in Malaysia also relfect poor energy performance in the buildings and wastage of energy consumption. Furthermore, the increase of oil prices and environmental issues over the past few decades have attracted global concerns and lead to a call for better use of energy in buildings. Therefore, the energy inefficiency in buildings has become a major concern for researchers, academics and industry to identify factors that become barriers to energy savings [11].

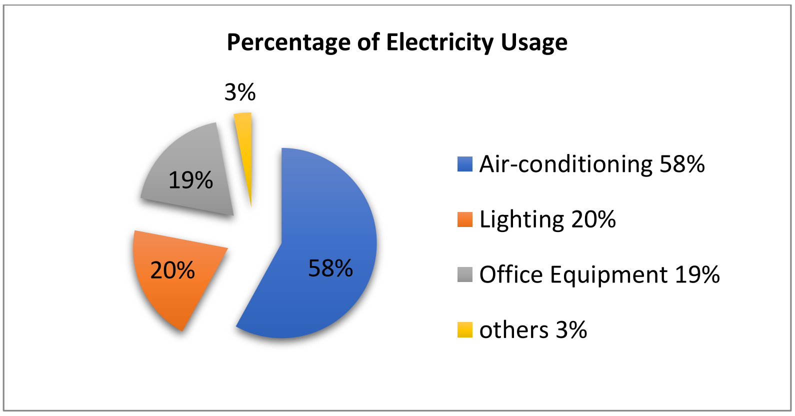

Fig. 1. Typical electricity usage in office buildings in Malaysia [5]

Building management undertake an energy audit by hiring a certified energy firm from a registered energy service company (ESCO). Calculations using the formula of Building Energy Index (BEI) is to obtain the energy performance measurement of buildings. Raw data is based on total energy used in a building for one year in kilowatts hours divided by the gross floor area of the building in square meters. The calculation results allowed comparison with other reference values of the index from other similar buildings.

A study by the Malaysia Green Technology Corporation (MGTC) concludes that majority of office buildings in Malaysia have reached the BEI in the range of 200kWh/m^2/year to 250kWh/m^2/year (Figure 2) which shows the inefficient use of energy during operation stage of the buildings [12]. There are some internal and external factors that contribute to energy-efficient issues, but most of the buildings in Malaysia were design without taking energy conservation into account [13–15].

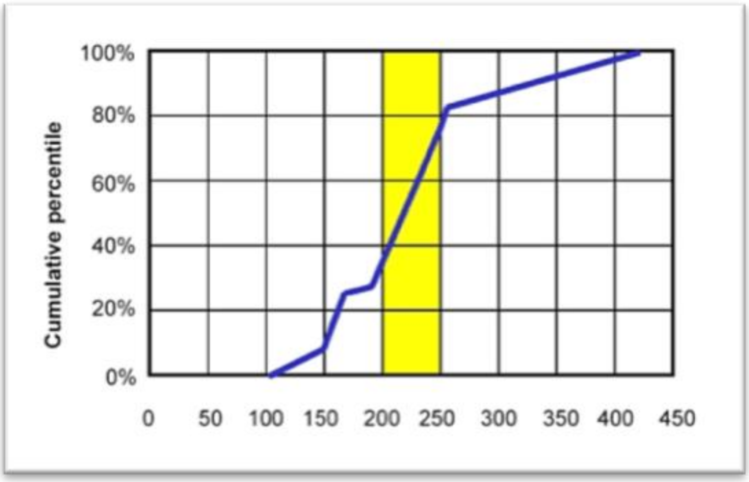

Fig. 2. Building energy efficiency index (kWh/ m^2/ year)[12]

To resolve the inefficient use of energy in office buildings, the energy management program can be adopted in order to optimize energy consumption in the buildings. These involves electrical engineering expertise to study the energy efficiency, control system [16,17] energy prediction [16,18] design strategies [7,19], and intelligent system [7,16-21]. However, this program is very expensive and taking a long period of time to implement especially in multi-story office buildings.

Alternatively, energy saving activities can be done by implementing a low-cost and no-cost energy-efficiency measures. There are several activities that can be implemented immediately, in which some of these activities have yielded immediate returns in a short period of time [22].

3. Methodology

According to Tahir *et al.,* [22] and Suleiman *et al.,* [23], the energy saving approach through the practice of low-cost and no-cost energy-efficiency measures provides the best savings when operating and capital costs are high in managing a building. Among the approach and practices of low-cost and no-cost energy-efficiency measures that can be implemented in office buildings are as follows.

3.1 Engage in Energy Efficiency Practices

It is important to cultivate a culture of energy saving among occupant in office buildings. Occupant attitude and behavior such as duration of occupancy, operation and activity that affect for example lighting and cooling usages in a building, has significant consequences in energy consumption.

This simple role by occupant to reduce the compound energy consumption by switching off all lighting, air conditioning, computers and office equipment when they are not in use. They should identify office equipment that were left idol which can be switched off and/or using the power management feature. The awareness in energy efficiency goes hand-in-hand with using computers and office equipment equipped with energy saving features. Use of shades and blinds to reduce heat, is very important for controlling direct sunlight through glass walls, windows and doors. It is also to provide adequate electric and natural lighting during sunny days. By adopting these energy savings measures, the savings rate will be significantly high on the energy consumption.

3.2 Simple Maintenance Practices

Adjusting the thermostats according to changes in weather or season and setting the thermostat after office hours or when the building is out of operation; are simple maintenance procedures that can be implemented. It is important for the maintenance personnel to keep records or operational documents on energy consumption as to keep track of the energy consumption trend. Cleaning the dust filter on split air conditioners should be done every month to avoid less efficient use of energy and to sustain indoor air quality. Likewise cleaning the evaporator and condenser coils on air-conditioners or chillers on planned and regular basis. If there is a leak in the pipes and insulation, the damaged pipes and insulation must be repaired immediately. Hence, proper maintenance of heating, ventilation, and air conditioning (HVAC) system can save about 15% of energy consumption.

3.3 Energy Efficiency, Conservation and Awareness Programs

Management can play an important role by promoting energy awareness programs such as energy savings campaign, seminar, workshop or simple energy management incentives on regular basis. This would be an encouragement towards energy efficiency culture. Such activities must involve the participation of all levels of employees within the organization. Teams with representatives from all departments appoints champions to communicate awareness initiatives at the department level. Through each department and unit, the champions identify energy efficiency opportunities to be implemented in their workplace. Once the awareness program implemented, evaluate the impact of the program and share the results with all employees. Savings estimates from such activities is about 5% to 15% if implemented diligently and involves the top management.

In this study, energy audits have been conducted at the Chancellery building via inspection, survey and analysis of energy usage to obtain basic information and data for three years. Using the guidelines published by the Energy Commission, three frequently used methods in energy auditing is adapted;

Benchmarking - Establishing benchmarking consumption by comparing the measured consumption to other similar buildings (office buildings). It is necessary to identify building energy saving potential, hence this study used Building Energy Index (BEI) as a performance index [24].

Preliminary Audit - This method is known as the simplest and quickest type of audit, involves minimal interviews, a brief review of utility bills and other operating data and a walkthrough to familiarize with the building operation.

General Audit - The audit expands the preliminary audit by collecting more detailed information about building operation. Utility bills are collected for 36 months period to evaluate energy usage profiles. Additionally, in-depth interviews with facility operation personnel have been conducted to get a better understanding of energy consuming systems.

4. Results and Discussion

The Chancellery (Figure 3) is a large office building that is specially constructed as the main administrative building within the campus. The building is located on the main road of the campus and is easily accessible to the offices. The 25-year-old building locates several administration offices such as the Vice-Chancellor's Office, Office of the Deputy Vice-Chancellors, Registrar's Department, Treasury Department, Department of Academic and Student Affairs and the UUM Gallery.

The Chancellery is a multi-storey building with gross floor area of 8,983m^2. In front of the building is a spacious parking area surrounded by ornamental plants and flowers. At the rear is a very wide assembly area known as Dataran Perdana. A fountain located in the middle; an open foyer or landing and a sitting area with plants and flowers; and connected to the library building in the north and a building that houses U-Assist Unit in the south.

Fig. 3. The Chancellery building and its surrounding

The Chancellory building has the advantage of being located in a green valley surrounded by hills and tall trees. Unlike other university campuses which are located in urban areas, there is no skyscraper or other nearby building which may reflect excessive light and heat during afternoon. This office building operates from 7:30 am to 5:30 pm just like other office buildings within UUM campus and caters up to 400 staff.

As a regular administrative function, the energy consumption in the Chancellery building is commonly on air-conditioning, lighting and office equipment. The electricity consumption was recorded through the collection of monthly electricity bills for the past three years from 2012 to 2014 (Table 1). Originally, the data were collected until 2015 however due to some errors, certain months do not have the correct reading. Thus, only data from 2012 to 2014 has been compiled in this study.

Table 1
Energy consumption in 2012 until 2014

Month	2012	2013	2014
Jan	126000	101039	125041
Feb	156000	104007	125809
Mar	110000	230350	193034
Apr	130000	182993	127888
May	141751	186726	132752
Jun	153445	102710	131690
Jul	157872	130906	141379
Aug	167766	117816	141379
Sep	168166	155690	149056
Oct	66111	118305	235234
Nov	150889	198985	195234
Dec	163961	117210	116273

At the beginning of the year 2012, there was slightly increase in energy consumption for February amounting to 156,000 kWh; an increase of 30,000 kWh compared to the previous month. However, there was a sudden decline a month later with 110,000 kWh before rising again from April to September. Although semester break is in mid-January to mid-February; a week off in April and two months semester break at the end of June until early September, did not show any significant change to the pattern of energy usage in this building. But the rate of electricity consumption went down in October with a total consumption recorded was 66,111 kWh before returning to the regular usage of 150,889 kWh in November and 163,961 kWh in December 2012. Total energy consumption for the year 2012 was 1,691,961 kWh.

The energy consumption of the building in 2013 began with quite low energy usage but increased in February and a sharp increase from March (230,350 kWh). Then the energy consumption in April and May decreased significantly to the consumption around 180,000 kWh. The month of June recorded the second lowest consumption for the year. Then, the energy consumption in the Chancellery fluctuates until November 2013 consuming 198,985 kWh being the second highest energy usage after March. Total energy consumption in the year increased to 1,746,737 kWh.

Energy consumption in 2014 appears with two peaks showing the higher usage of energy, increased sharply in March (193,034 kWh) and October (235,234 kWh). In other months, the total energy consumption is much lower, of not more than 150,000 kWh/month. High energy consumption in March and October can be attributed to the influx of new and returning students in mid-January and September, involving high data input in the office of the Registrar and Bursar. The high energy consumption also occurred in March in previous year, which reached 230,000 kWh.

Based on the observations and data collected, the monthly energy consumption trend for the Chancellery building is difficult to predict. Even the energy consumption trends for certain months fluctuates either ascending or descending drastically in the three years. The most noticeable example is that in October 2012, data showed only 66,111 kWh of energy consumption, while in 2013 it increased significantly at 118,305 kWh and 235,234 kWh in 2014. However, there is no significant difference in energy consumption trends either during semester breaks or during normal teaching sessions.

4.1 Building Energy Index (BEI)

Calculation for Building Energy Index (BEI),

$$BEI = \frac{\text{Total Energy Used (kWh/year)}}{\text{Gross Floor Area (m}^2\text{)}}$$

The purpose of Building Energy Index (BEI) is to obtain the performance index of a building. In this study, raw data is based on total energy consumption in the Chancellery building for three years in kilowatts hours (kWh) divided by the gross floor area of the building in square meters (m^2). Based on the monthly electricity bills, the energy consumption of the Chancellery building was very high each year as it is the main administrative building in the campus operating throughout the year.

There are varieties of electric density loads on functional and aesthetic requirements, and the operating hours. The electrical usages for the buildings is distributed to the use of lightings, plug loads and others while artificial lighting system is used to illuminate the interior office space and external areas such corridors and building façade. There are also other minor electrical appliances, such as the audio/visual, gadgets and office equipment. Hence, as shown on the monthly electricity consumption data, the energy consumption (kWh) of Chancellery buildings was very high throughout the 12 months cycle. Overall, energy usage of the Chancellery building is very uneven throughout the year (Table 2).

Table 2
Building Energy Index

Description		Chancellery	
Year	2012	2013	2014
Annual Energy Consumption (kWh)	1,691,961	1,746,737	1,814,769
Gross Floor Area (m^2)	8983	8983	8983
BEI in kWh/m^2/year	188.35	194.45	202.02

The MS 1525:2007 Standard indicates that any building which implements energy efficient measures, can achieve the BEI of 136 kWh/m^2/year. According to [15], based on the energy audit results shows that majority of Malaysia office buildings had the BEI in the range of 200 to 250 kWh/m^2/year. Currently, the Chancellery building of UUM has the BEI in the range of 180 to 210 kWh/m^2/year and the potential energy reduction is very high and could be achieved if all energy saving measures are implemented.

Based on the records of monthly electricity consumption, the Chancellery building has a potential to reduce 52.35 kWh/m^2/year in 2012, 58.45 kWh/m^2/year in 2013 and 66.02 kWh/m^2/year in 2014 in energy consumption. Based on the annual rate of BEI reduction to meet the standards, then the average 59.63 kWh/m^2/year is very high and the potential for savings is significant (Table 3).

Table 3
Potential energy consumption reduction

Description	Chancellery		
	2012	2013	2014
BEI in kWh/m^2/year	188.35	194.45	202.02
BEI MS1525:2007 in kWh/m^2/year	136	136	136
Potential energy savings in kWh/m^2/year	52.35	58.45	66.02

4.2 Recommendation

There are some initial suggestions for immediate solution to energy efficiency and savings in the Chancellery building that can be implemented, among others are

i. Increase awareness of energy efficiency among the building occupant.
ii. Providing understanding and importance of energy efficiency in energy management and budgeting to top management.
iii. Give emphasis to the purchase of energy-efficient electrical assets, equipment, fittings and devices.
iv. Introduce and activate the existing energy saving functions in all computers, office equipments and air conditioning (split units) e.g. energy saver, sensors, inverter and sleep mode.
v. Cleaning the dust filter on split air conditioners and to clean the evaporator and condenser coils on regular basis.
vi. Old buildings usually have equipment leakages and the damaged insulation that must be replace and repaired immediately.
vii. Using shades and blinds to prevent heat gain, as well as to reduce sunlight directly through the windows, while allowing more natural light into the building.
viii. Adjusting thermostats according to weather or season and setting the thermostat after office hours when the building is out of operation.

5. Conclusion

This study has been carried out on energy consumption in the Chancellery building at UUM, where data are collected from three years electricity reading and observations; and discussions with UUM's Department of Development and Maintenance (JPP). The Chancellery building accommodate administrative functions that operate throughout the year unlike the academic purpose building such as the faculty buildings, lecture halls, library, food courts, sport complex and student activity center which less or do not operate during university breaks.

After calculating the BEI, there is a clear indication that the total amount of electricity consumption in the Chancellery building is high. Due to concerns over the significant increase in energy consumption in the building, some initial proposals for immediate solution of the energy inefficiency problem have been proposed and this does not involve any additional costs or a burdensome budget to the operational cost of the building. Further study need to be carried out to identify the factors that affect the fluctuation of energy consumption in the building in certain months. These studies will be continued to determine the actual usage of electricity for the year 2015 until 2017.

References

[1] Kamaruzzaman, Syahrul Nizam, and Nursyahida Zulkifli. "Measures for building lighting performance in Malaysian historical buildings: A systematic review." *Journal of Surveying, Construction and Property* 5, no. 1 (2014): 1-15.

[2] International Energy Agency, (2015,Oct. 30). *International energy agency*. [Online]. Available: http://www.iea.org/topics/energyefficiency/.

[3] K. Gillingham, R.G. Newell, and K. Palmer, (2018,May 22). *Energy Efficiency Economics and Policy*. [Online]. Available: http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-DP-09-13.pdf.

[4] Choong, Weng Wai, Yin Fong Chong, and Sheau Ting Low. "Implementation of energy management key practices in Malaysian universities." *International Journal of Emerging Sciences* 2, no. 3 (2012): 455.

[5] Energy Information Unit, *Malaysia Energy Statistics Handbook*. Putrajaya: Suruhanjaya Tenaga, 2014.

[6] Haw, Lim Chin, Elias Salleh, and Philip Jones. "Renewable energy policy and initiatives in Malaysia." *Int J Sustain Trop Des Res Prac* 1, no. 1 (2006): 3.

[7] Georgiadou, M. C., T. Hacking, and P. Guthrie. "Future-proofed energy design for dwellings: Case studies from England and application to the Code for Sustainable Homes." *Building Services Engineering Research and Technology* 34, no. 1 (2013): 9-22.

[8] Moghadam, MH Nejad, F. Baharum, and N. Md Ulang. "Influence of Energy Efficient Elements on Energy Saving in Residential Buildings: Case Study of Three Apartments in Penang." In *MATEC Web of Conferences*, vol. 17, p. 01019. EDP Sciences, 2014.

[9] M. N. M. Nawi, F. Baharum, M. F. Rajemi, J. A. Ibrahim, and M. Z. Tahir, "Energy Management: A Case Study on the Government Office Building in Putrajaya." in *Reegetech*, 2014, pp. 63–68.

[10] Noranai, Zamri, and Mohamad Najib Kammalluden. "Study of building energy index in Universiti Tun Hussein Onn Malaysia." *Academic Journal of Science* 1, no. 2 (2012): 429-433.

[11] Li, Xiaoli, Chris P. Bowers, and Thorsten Schnier. "Classification of energy consumption in buildings with outlier detection." *IEEE Transactions on Industrial Electronics* 57, no. 11 (2009): 3639-3644.

[12] A. C. S. Aun, “GREEN BUILDING INDEX – MS1525: Applying MS1525:2007 Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings,” in *GBI CPD Seminar*, 2009, pp. 1–22.

[13] Zain-Ahmed, A., K. Sopian, Z. Z. Abidin, and M. Y. Othman. "Renewable energy, buildings and the fuel crisis." In *International Conference on Construction and Building Technology*, no. 02, pp. 13-24. 2008.

[14] Tahir, Mohamad Zamhari, Mohd Nawi, Mohd Nasrun, and Faizal Baharum. "Implementation of energy management in designing stage of building construction." *Advances in Environmental Biology* 9, no. 5 (2015): 157-159.

[15] Zainordin, Nadzirah and Siti Marina Abdullah, "Users’ perception towards energy efficient buildings." *Asian Journal Of Environment-Behaviour Studies* 3, no. 9 (2012): 91-105.

[16] Eisenhower, Bryan, and Igor Mezić. "Uncertainty in the energy dynamics of commercial office buildings." In *2012 IEEE 51st IEEE Conference on Decision and Control (CDC)*, pp. 6945-6950. IEEE, 2012.

[17] Chiogna, M., A. Mahdavi, R. Albatici, and A. Frattari. "Energy efficiency of alternative lighting control systems." *Lighting Research & Technology* 44, no. 4 (2012): 397-415.

[18] Liu, Dandan, and Qijun Chen. "Prediction of building lighting energy consumption based on support vector regression." In *2013 9th Asian Control Conference (ASCC)*, pp. 1-5. IEEE, 2013.

[19] Hartungi, Rusdy, and Liben Jiang. "Energy efficiency and conservation in an office building: a case study." *International Journal of Energy Sector Management* 6, no. 2 (2012): 175-188.

[20] Anastasi, Giuseppe, Francesco Corucci, and Francesco Marcelloni. "An intelligent system for electrical energy management in buildings." In *2011 11th International Conference on Intelligent Systems Design and Applications*, pp. 702-707. IEEE, 2011.

[21] Bocheng, Zhong. "Design of building energy monitoring and management system." In *2012 Second International Conference on Business Computing and Global Informatization*, pp. 645-648. IEEE, 2012.

[22] Tahir, Mohamad Zamhari, Mohd Nasrun Mohd Nawi, and Amlus Ibrahim. "Low-cost and no-cost practice to achieve energy efficiency of government office buildings: A case study in federal territory of Malaysia." In *AIP Conference Proceedings*, vol. 1761, no. 1, p. 020101. AIP Publishing, 2016.

[23] Suleiman, Sani Malami, Muhammad Rabiu Abbas, and Abubakar Sadiq Aliyu. "Investigation of Energy Conservation Potentials in Kaduna Polytechnic, Nigeria." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 30, no. 1 (2017): 12-20.

[24] Abdullah, Mohammad Kamil, and Mohd Hafiz Mohamad. "Building Energy Performance: A Case Study at G2 Building UTHM." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 50, no. 2 (2018): 161-169.