Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

A Case Study on Energy Efficiency of Lestari Building at UPNM

Suresh Thanakodi[1,2,*], Muhammad Azlan Mohd Hassan[3], Nazatul Shiema Moh Nazar[3], Nur Hidayah Ismail[3], Azharudin Mukhtaruddin[3], Vignesh Dhakshinamoorthy[4]

1 Department of Industrial Revolution, Centre of Cyber Security & Digital Industrial Revolution, Universiti Pertahanan Nasional Malaysia, Kem Perdana Sungai Besi, 57000 Kuala Lumpur, Malaysia
2 Department of Science and Maritime Technology, Faculty of Science and Defence Technology, Universiti Pertahanan Nasional Malaysia, Kem Perdana Sungai Besi, 57000 Kuala Lumpur, Malaysia
3 Department of Electrical and Electronics Engineering, Faculty of Engineering, Universiti Pertahanan Nasional Malaysia, Kem Perdana Sungai Besi, 57000 Kuala Lumpur, Malaysia
4 Department of Mathematics, School of Engineering and Technology, CMR University, 562149 Bangalore, India

ARTICLE INFO

Article history:
Received 16 August 2023
Received in revised form 14 October 2023
Accepted 2 November 2023
Available online 31 December 2023

Keywords:
Energy efficiency; building energy intensity; national building energy label

ABSTRACT

With the advancement of Industrial Revolution 4.0, the trend of global energy consumption seen to be rising and one of the largest energy utilisers is from the commercial building sector. In respecting to the Paris Agreement 2015 to reduce the greenhouse gases, various efforts and measures have been taken by the Malaysian authorities in ensuring the usage of energy in efficient ways especially in government owned buildings and one of the measurements is by introducing the Energy Efficient Building's Star Ratings. Therefore, this paper intends to explore and present a case study of a two-year energy consumption and its pattern at Lestari Building, Universiti Pertahanan Nasional Malaysia (UPNM). For this study, data such as gross floor area of Lestari Building, total electricity consumption, maximum demand for the Lestari building were obtained from January 2019 up to December 2020 using the desktop audit method. The obtained results have been analysed and presented in terms of cost of electrical consumption, building energy intensity (BEI) and energy label for the Lestari building according to the National Building Energy Labelling Standard. Based on the study conducted, Lestari Building obtained a 3-Star rating for the year 2020 in comparison to the year 2019 with just a 2-Star rating. In conclusion, several strategies for further improvement of the energy efficiency and building performance were also suggested in this paper such as the introduction of PIR sensors in the parking lot of Lestari building.

1. Introduction

The residential and commercial sector is one of the largest energy consumers in the country, accounting for over 14% of total energy consumption in 2016, while in different parts of the world, the construction sector consumes somewhere from 20% to 60% of total energy consumptions as stated in Ali *et al.,* [1], Nabil and Labidine [2], and Arab *et al.,* [3]. This includes the development of

* *Corresponding author.*
E-mail address: sureshcoding1983@gmail.com (Suresh Thanakodi)

https://doi.org/10.37934/araset.35.2.1121

privately owned and government university sectors. As the nation progresses towards science and technology, there's a huge demand for knowledge and skilled workers which the higher education institution need to cater for the market's employability. As a result, more varsities, and colleges in operational increases the energy demand and with the higher number of population and activity in campus makes the varsity known to be one of the heavy energy users in the commercial building category as taken from Muhammad [4], Bakar *et al.,* [5], and Subramaniam *et al.,* [6]. Therefore, there is a need for necessary actions in using energy efficiently at campus.

The requirement for energy efficiency in a building structure is compelled by increased operation and maintenance costs, as well as the ever-increasing cost of electricity as stated by Bamgbade *et al.,* [7] and Khean *et al.,* [8]. Utilizing energy efficiently in buildings seen as a method to improve the efficiency of a building's operations and its effectiveness which resulting in reducing the electricity wastages and its' cost as stated by Nawi *et al.,* [9] and Khean *et al.,* [10]. Authors believe that to achieve energy efficiency in buildings, it is critical to understand the definition of energy efficiency and the sectors involving of it. Energy efficiency is defined by Gillingham *et al.,* [11] as the energy services provided per unit of energy input into the creation of essential energy services such as heating and lighting. It's also known as a technique of managing and sustaining the rate of increase in energy consumption or in other word, using the same or less energy to get a better output or using less energy to complete the same activity as accordance to Kamaruzzaman and Zulkifli [12] and Jamaludin *et al.,* [13]. Hence, it's very vital that the proper energy management strategies are in place to achieve the goal of utilizing energy efficiently.

Energy management is known as a practice of tracking and optimizing energy consumption to save energy in a building. An organization's management plays a key role by encouraging energy awareness initiatives on a regular basis, such as energy conservation campaigns, seminars, workshops, or simple energy management incentives to motivate everyone and instil the culture of using energy efficiently at respective organizations. The usage of high energy efficiency equipment's (rated 5 stars by Suruhanjaya Tenaga-ST) in an organization such as for heating or cooling can save energy costs while also helping to conserve the energy generated, particularly from non-renewable energy sources in synchronous [14].

This study encompasses the analyses and findings on energy management and energy efficiency of Lestari building in UPNM using the desktop audit method which involves obtaining load information, data, and records prior to onsite visit that are in line with Kandt [15]. This paper presents the analyses of energy consumption and its pattern besides of identifying and proposing the suitable strategies to be implemented in achieving the goal to become an energy efficient university.

2. Methodology

This section summarises the strategies taken to accomplish the project's objectives. The strategy explains the project's planning by stages. Figure 1, indicate the overall flow of this project. At first, the project involves researching and collecting literature reviews from various Scopus and WOS indexed journals and articles related to energy efficiency management. The goal of this step is to gather the necessary information and gain the necessary knowledge to complete the project. The next step is to identify the problem statement, objectives, and scope of work for this project. This step is important to get a clear goal of the project and outline the scope for the project. Then, the flowchart continues with collection of continuous electricity consumption data for Lestari building.

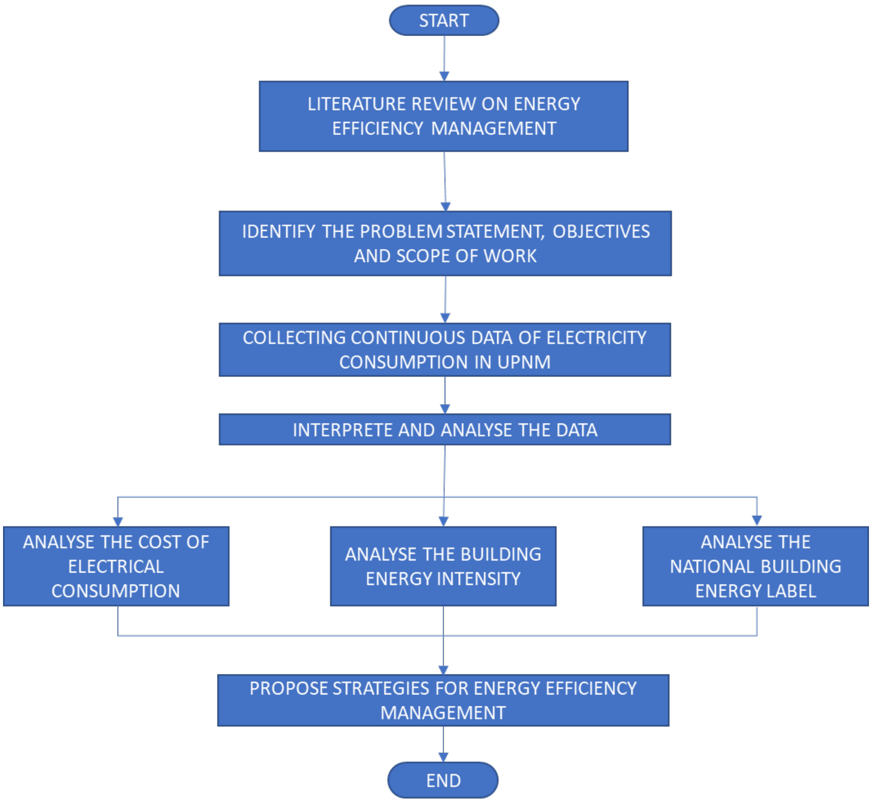

Fig. 1. Flowchart of the project

In order to see the pattern of electricity consumption, the electrical data has been interpreted and analysed. Then, the research work continued with three different analysis which is on the cost of electrical consumption, the building energy intensity, and the national building energy label. These three analyses have been based on the continuous data that been interpreted and analysed in the previous stages of this project. Finally, this work concludes by proposing the suitable strategies that can help the university's management to achieve the energy efficiency in Lestari building.

2.1 Data Collection

This case study is continued with the collection of electricity consumption data for Lestari building. The data collection of electricity consumption for Lestari building was obtained from UPNM's JPP (Jabatan Pembangunan & Penyelenggaraan) for the year of 2019 and 2020. The collected data then been used to investigate the electrical energy consumption's trend and maximum demand using desktop audit method. Electricity demand indicates the rate at which electrical energy is consumed for a required output rating in units of kW, while electricity consumption defined as the amount of electrical energy which has been utilised over a certain time, in units of kWh. The obtained data was also verified by the researchers through conducting multiple site visit at Lestari block in complement to the usage of desktop audit method.

2.2 Building General Description

Universiti Pertahanan Nasional Malaysia (UPNM) is a public university that is located at Kem Sungai Besi, Kuala Lumpur, Malaysia. It is a university consists of 48 main building with a land area of 694,646.95 m^2 (171.651 acres). Lestari building is one of the academic buildings located in UPNM. It is a 7-storey building that has a gross floor area of 14,382 m^2 that holds several classrooms, halls, and offices. The building is categorized as a commercial building that has various operating hours depending on the program of academic class schedules. Generally, normal office and lecture hours are on working days only, which is from Monday to Friday from 8.00 am to 5.00 pm.

2.3 Calculation Bill of Lestari Building

UPNM only has a single bill of electricity which is indicating the total electrical consumption for all the buildings in the campus. There is no bill for each of the buildings inside the campus. This paper presents the electricity cost for the consumption in Lestari building as a case study. The energy tariff for UPNM according to Tenaga Nasional Berhad (TNB) classification is C1 type and it has mainly five major components as stipulated in the TNB's C1 classification type as tabulated in Table 1.

Table 1
Energy Tariff

Components on Energy Tariff for UPNM	Tariff
Electrical Energy Consumption = (A)	RM 0.365/kWh
Cost of Maximum Demand = (B)	RM 30.30 / kW
Renewable Energy Fund (RE Fund) = (C)	1.6% from total bill
Imbalance Cost Pass-Through (ICPT) = (D)	-RM 0.0200 / kWh
Discount for Government Aided Higher Educational Institution (G-HEI) = (E)	10%

Based on Table 1, the electricity consumption cost for Lestari building can be calculated by using Eq. (1).

$$Total\ Cost = A + B + C + D - E \tag{1}$$

where A is the cost of electrical energy consumption, B is the cost of maximum demand, C is the cost of RE fund, D is ICPT and E is the discount for G-HEI.

2.4 Building Energy Intensity Benchmark

BEI is a tool that used as a benchmark for monitoring the energy performance of any building. According to the Malaysian Standard, MS1525: 2019 (third revision) [16] stated that the benchmark for Building Energy Intensity (BEI) of an office building that complies with this standard is 200 kWh/m^2/year. The equation given by the Malaysian Standard for BEI benchmark is calculated as in Eq. (2).

$$BEI_{benchmark} = \frac{(TBEC - CPEC) \times (52)}{(GFAexcl\ carpark) \times (WOH)} \tag{2}$$

where TBEC indicates Total Building Energy Consumption in kWh/year. Another term that used in the equation is CPEC which is defined as Car Park Energy Consumption in kWh/year. Car park of the Lestari building is located at the basement of the building, and the number 52 in the equation denotes as 52 weeks per year. For GFA, it is defined as Gross Floor Area in m^2 and according to equation, the carpark gross floor area is excluded. Last term in the equation is WOH defined as Weighted Weekly Operating Hours of the Office in h/week.

2.5 National Building Energy Label

This energy label method is introduced by the Suruhanjaya Tenaga Malaysia (ST) that can be implemented in any building such as government office, hospital, university, and schools as referred to Suruhanjaya Tenaga Malaysia [17]. The main purpose of this labelling is to improve the building energy efficiency by awarding the rating of the building between 1 – 5 stars that indicates the building energy efficiency as shown in Table 2. This label assists in providing information about a building's energy performance. The rating starts from 1 star which signifies to highly inefficient while 5 star means most efficient building.

Table 2
Star Award (Rating) in relevant to BEI Index

STAR	BEI Range
5-Star	BEI ≤ 100
4- Star	100 < BEI ≤ 130
3- Star	130 < BEI ≤ 160
2- Star	160< BEI ≤ 250
1- Star	BEI > 250

3. Results

In this section, the authors present the obtained results from the conducted case study and the discussions of it. This section made up of three main findings which are the electrical consumption, maximum demand, and cost of electrical consumption of the Lestari building.

3.1 Lestari Building Consumption

The first analysis of this paper is on the electrical consumption of Lestari building. Figure 2 shows the comparison of electrical consumption (kWh) for Lestari building between the year 2019 and 2020.

The total consumption of electrical energy in 2019 is higher compared to 2020. In 2019, the total consumption of electrical energy is 2,576,270 kWh while in 2020 the consumption is 1,393,141 kWh. This shows that the total electrical consumption has decreased about 45.9% from 2019 to 2020.

According to Figure 2, the highest consumption in the year 2019 is in the month of May which is 259,450 kWh and the lowest consumption is in October which is 167,790 kWh. For 2020, the highest consumption is in the month of January which is 230,230 kWh while in October the consumption is 25,540 kWh which is the lowest consumption of 2020.

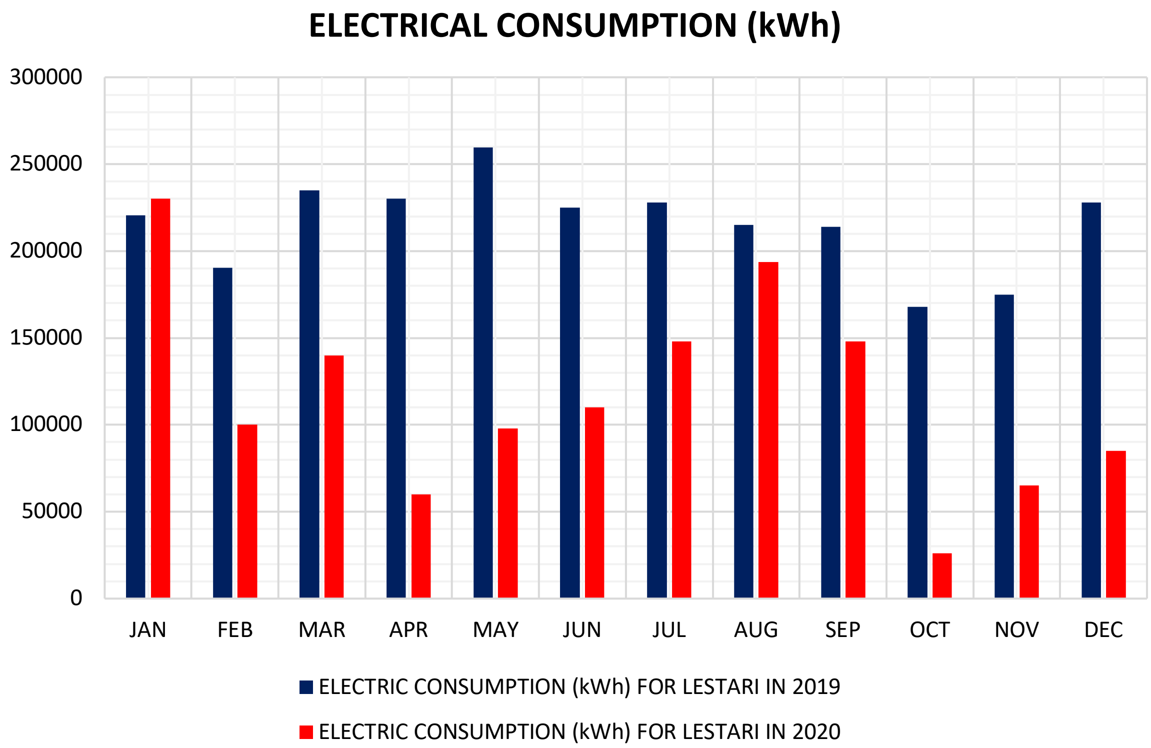

Fig. 2. Comparison of electric consumption between the year 2019 and 2020

Authors strongly believe the total reduction of electrical energy utilization in the year 2020 due to the lockdown as an impact of the covid pandemic. In addition, there is still energy required during the lock down due to some basic activity whereby some essential staffs were still on standby working mode at office taking turns to make sure that the students either off campus or still left in campus with the university staffs' wellbeing were taken care off. In a nutshell, the impact of the pandemic can be seen positive in the electrical energy sectors for varsities operators and education operators, as in for the Lestari building itself has significant decrease about 45.9% in the electrical energy consumption.

3.2 Lestari Building Maximum Demand

In this section, this paper presents the maximum demand of Lestari building. Figure 3 indicates the comparison of maximum demand for Lestari building between 2019 and 2020. Referring to Figure 3, maximum demand of 2019 is higher compared to the maximum demand use for 2020. Maximum demand in 2019 appears with three peaks showing higher demand of above 800 kW which is in March (843 kW), August (810 kW) and in September (860 kW). The highest max demand in 2019 is in the month of September with 860 kW and the lowest was observed at 341 kW which is in Feb 2019. The higher demand can be attributed to the use of the exam hall by the student for final semester examination as the Lestari building holds major examination halls that almost 80% of the university final examinations are held here.

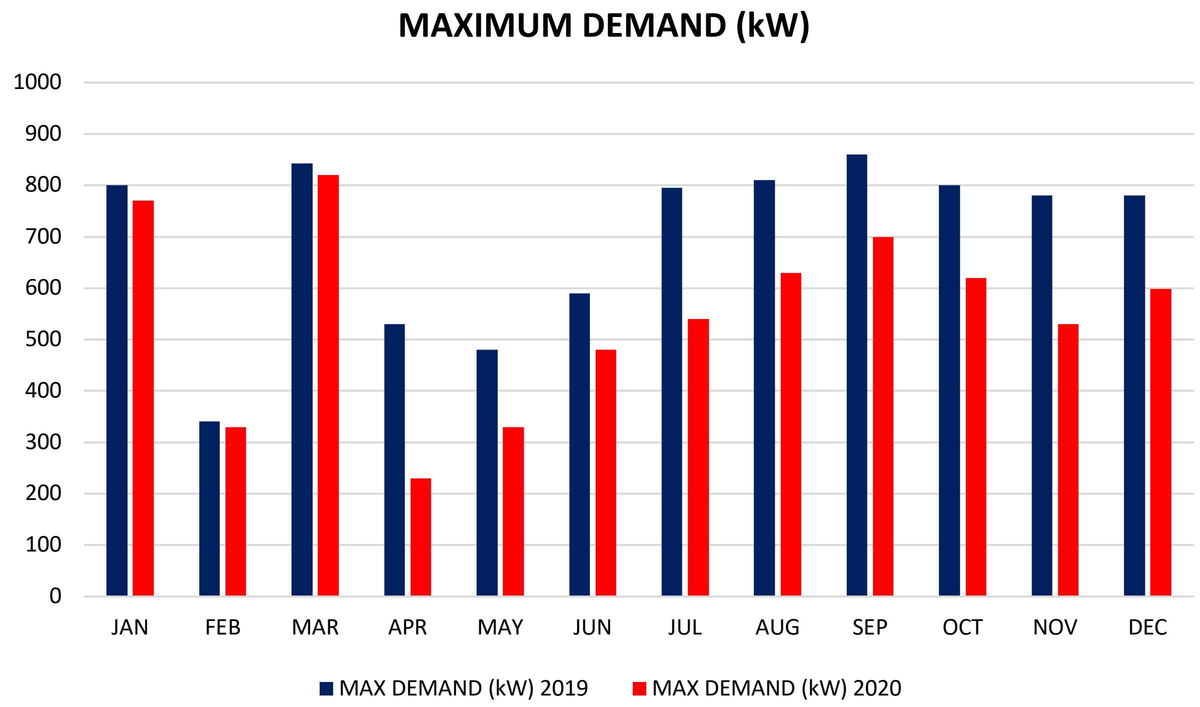

Fig. 3. Maximum demand of Lestari building

For overall of 2020, the authors observed the decreasing trend in maximum demand compared to 2019 due to the work from home culture and online classes implemented as an impact from covid pandemic. It's observed that in March the maximum demand is the highest, which is 820 kW and in April the maximum demand dropped to the lowest maximum demand of the year. The fluctuation of the maximum demand in March can be attributed to the use of the main hall in level 5 and level 6 for occurrence of the academic events such as the Series of Professors Inaugural Speeches were conducted. On the other hand, the interesting fact observed, although the lockdown in Malaysia started on 18th March 2020, it's noticeable that the maximum demand 2020 is lower from January before the lockdown commences. This shows that the efforts in using LED lights in some areas of Lestari building and making sure the air-conditioning settings to be within the range of 24℃ - 26℃ turns out to be effective in reducing the maximum demand.

3.3 Electrical Consumption Cost of Lestari Building

Another parameter being presented in this paper is the electrical consumption cost in terms of Ringgit Malaysia (RM). Figure 4 shows the comparison of electrical consumption cost in RM for Lestari building between the year 2019 and 2020. Based on the energy tariff category Type C1 provided by TNB, the calculation for the electrical consumption cost for Lestari building was conducted and the obtained results were presented in Figure 4. It's observable that the cost of the consumption is affected directly by the electrical consumption and maximum demand of Lestari building. Referring to Figure 4, the cost of consumption for 2019 is higher compared to 2020.

At the beginning of the year 2019, there was a sudden decline in cost of energy consumption for February amounting to RM 70,439; a decrease of RM 20,862 compared to the previous month. However, a month later, the cost of consumption rose to RM 98,022. Total cost of electrical consumption for the year 2019 is RM 1,045,519.

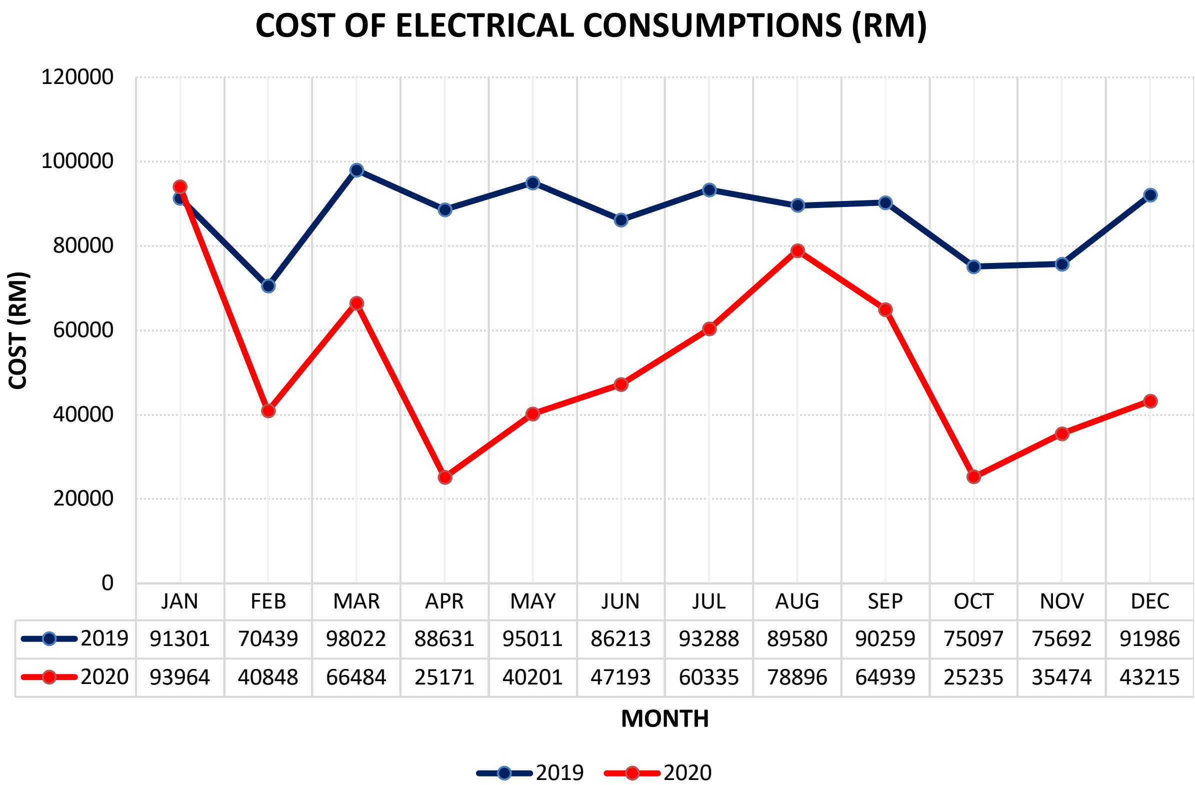

Fig. 4. Cost of Electrical Consumptions for Lestari Building in Ringgit Malaysia (RM)

Based on Figure 4, the authors found out that the monthly cost of electrical consumption pattern for the Lestari building is difficult to forecast based on the observations and data collected. This is due to the unprecedented nonacademic activities conducted at the Lestari Hall during after office hours or weekends such as meetings and classes for the Reserve Officer Training Unit (ROTU). Even the energy consumption trends for specific months have shifted dramatically over the two years, either rising or declining. The most notable example is that cost of energy consumption was RM 88,631 in April 2019, but it decreased dramatically in 2020 to RM 25,171. The cost of consumption drops by 71.6% from 2019 to 2020. It is the biggest drop between the two years. The authors believe the main factors for the reductions were the study from home and work from home policies due to the pandemic's Movement Control Order (MCO).

3.4 Findings on Building Energy Intensity (BEI)

The Building Energy Intensity (BEI) is used to calculate a building's energy performance index. According to the analysis and calculation carried out using Eq. (2), the analysis shows that in 2019 the TBEC is 2,576,270 kWh/year while for 2020 it is 1,393,141 kWh/year. According to the Table 3, the total energy consumption for the car park area (CPEC) at Lestari Building is 13,245.12 kWh per year. Table 3 describes the type of lamp with its total number of respective units used at the Lestari Carpark areas. The total consumptions for car park (CPEC) were obtained to use for the BEI calculations and later part for the STAR award (ratings).

Table 3
Car Park Energy Consumption

Type	Total unit	Total consumption
Fluorescent T8 4ft (36 W)	37 unit	11,668.32 kWh/year
Fluorescent T8 2ft (18 W)	10 unit	1576.8 kWh/year
	Total consumption	13,245.12 kWh/year

There is 365 days per year and 7 days per week. Hence, the number 52 in the Eq. (2), denotes as 52 weeks per year. In order to order to obtain the BEI, the Gross Floor Area of Lestari building without carpark ($GFA_{excel\ carpark}$) also measured by the authors during the site inspection visit. Lestari is a seven-storey building with basement and following the 2nd equation, the basement of the building is neglected. This is because the basement of Lestari building is used as a carpark for lecturers, staffs, and visitors. The total gross floor area for Lestari building excluding the basement is 12,921 m^2. The gross floor area of each floor in Lestari Building is stated in the Table 4.

Table 4
Floor Plan of Lestari Building

Measured Area	Floor Size Area (m^2)
Basement	1,461
Ground floor	2879
1st floor	1820
2nd floor	1602
3rd floor	2445
4th floor	2307
5th floor	1171
6th floor	697
Total Lestari Floor Area (m^2)	14,382

WOH is defined as Weighted Weekly Operating Hours of the Office in h/week. The office hour at Lestari is from 8 in the morning until 5 in the evening. Hence, it's 9 hours of working time for 5 days in a week. Hence, the WOH for Lestari is calculated as 45h/week by omitting the unprecedented activities off working hours or days. The BEI benchmark then was calculated by using all the previously obtained value of Eq. (2). The result from the calculation concluded that for 2019, Lestari building has BEI of 229.2kWh/m^2/year while 2020 the BEI is 123 kWh/m^2/year.

After obtaining the BEI, authors proceeded with the National Building Energy Label parameter. According to the National Building Energy Intensity (BEI), Lestari building in the year of 2019 has a range from 160 to 250 kWh/m^2/year which is 2-star rating while for the following year which is 2020, Lestari building has a better result of BEI. In 2020, Lestari's BEI ranges between 130 to 160kWh/m^2/year which leads in achieving a 3-star rating award. This rating starting from 1 star which is highly inefficient while 5 star is for the most efficient building. Based on this rating, Lestari's energy performance getting better on 2020 compared to 2019 and authors believe it's the aftermath of MCO.

3.5 Recommendation for Energy Efficiency Management

Since TNB (Tenaga Nasional Berhad); the Malaysian electricity provider, bills UPNM as a whole campus, authors recommend the management to provide billing for every building or department in UPNM. By doing so in this way, authors believe that it will increase the awareness of the respective electricity consumer of each building in UPNM campus in line with Taib *et al.,* [18]. The reason is the awareness only comes when people talk about the cost of consumption in Ringgit Malaysia rather than discussing it in kWh. When each building owner or management observes the rising of consumption in the form of monetary (RM), the awareness shall arise and able to act quickly.

Other than that, based on the car park energy consumption, this study found out that the lighting system is lit up for 24 hours. Hence, this paper recommends the management to install PIR sensors for the lighting system at the car park of Lestari building to further reduce the electrical consumption of the building. Using this sensor, the lighting system will only light up when the sensor detects any motion by person or objects such as cars, motorcycle, and bicycle. Authors truly support the initiatives of changing all the existing fluorescent lamp to LED as suggested by authors from the previous studies and the implementation of air-conditioning settings policy in which the temperature need to be set within the range of 24℃ - 26℃ for further improvement of energy efficiency [19,20].

4. Conclusions

Based on this study, it is concluded that Lestari Building obtained a 3-Star rating for the year 2020 in comparison to the year 2019 with just a 2-Star rating. Authors believe that, apart from the current initiatives, the awareness on energy efficiency to the whole campus should be carried out frequently to improve the BEI index of UPNM overall. By having electricity energy saving month campaign, energy efficient captains at every floor level and monthly competition could motivate everyone in campus to be more energy efficient users. For the future scope of the research, authors strongly recommend doing research by obtaining the data of 2021 and 2022 to observe the post-pandemic trend of electricity usage and the impacts of new energy efficiency initiatives on overall of the UPNM BEI index.

Acknowledgement
Authors wish to thank all the staffs of the Department of Jabatan Pembangunan dan Penyelenggaraan (JPP) of Universiti Pertahanan Nasional Malaysia (UPNM) for guiding and providing their full cooperation in completion of this study. Our special gratitude also goes to Mr. Mohamed Nadhir Zainal Abidin from Suruhanjaya Tenaga Malaysia (STM) for his guidance on the information regarding Malaysian Standard's for Building Energy Intensity (BEI).

References
[1] Ali, Siti Birkha Mohd, Md Hasanuzzaman, N. A. Rahim, M. A. A. Mamun, and Unaizah Hanum Obaidellah. "Analysis of energy consumption and potential energy savings of an institutional building in Malaysia." *Alexandria Engineering Journal* 60, no. 1 (2021): 805-820. https://doi.org/10.1016/j.aej.2020.10.010

[2] Nabil, Meftah, and Mahri Zine Labidine. "Application Efficiency Measures Through TRNSYS Software on Algerian Building to Save Energy." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 93, no. 2 (2022): 160-172. https://doi.org/10.37934/arfmts.93.2.160172

[3] Arab, Yasser, Ahmad Sanusi Hassan, Zeyad Amin Al-Absi, Hussam Achour, Boonsap Witchayangkoon, and Bushra Qanaa. "Retrofitting of a High-Rise Residential Building for Energy Efficiency with OTTV as an Assessment Tool." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 102, no. 2 (2023): 110-119. https://doi.org/10.37934/arfmts.102.2.110119

[4] Muhammad, Hilmi Dzulkefli. "The energy audit process for universities accommodation in Malaysia: a preliminary study." In *IOP Conference Series: Earth and Environmental Science*, vol. 67, no. 1, p. 012027. IOP Publishing, 2017. https://doi.org/10.1088/1755-1315/67/1/012027

[5] Bakar, Nur Najihah Abu, Mohammad Yusri Hassan, Hayati Abdullah, Hasimah Abdul Rahman, Md Pauzi Abdullah, Faridah Hussin, and Masilah Bandi. "Sustainable energy management practices and its effect on EEI: a study on university buildings." In *Proceedings of the Global Engineering, Science and Technology Conference*, Dubai, UAE, pp. 1-2. 2013.

[6] Subramaniam, Abhiviran Vimal, Mohammed W. Muhieldeen, Rodney Tan Hean Gay, and Lim Chong Lye. "Reducing The Energy Cost of Buildings Using Shading Plates: Experimental and Numerical Study." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 94, no. 2 (2022): 1-12. https://doi.org/10.37934/arfmts.94.2.112
[7] Bamgbade, Jibril Adewale, Ahmed Mohammed Kamaruddeen, Mohd Nasrun Mohd Nawi, Rushami Zien Yusoff, and Ramli Azahari Bin. "Does government support matter? Influence of organizational culture on sustainable construction among Malaysian contractors." *International Journal of Construction Management* 18, no. 2 (2018): 93-107. https://doi.org/10.1080/15623599.2016.1277057
[8] Khean, Chang Choo, Zulkiflle Leman, Nor Mariah Adam, and Eris Elianddy Supeni. "Effects of Building Materials on Building Thermal Load in Malaysian Institutional Library." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 107, no. 2 (2023): 191-207. https://doi.org/10.37934/arfmts.107.2.191207
[9] Nawi, M. N. M., M. Z. Tahir, S. H. Ibrahim, F. Baharum, and Federica Agnese. "Energy Management Practice: A Case Study of University Utara Malaysia Main Administrative Building." *International Journal of Innovation, Creativity and Change* 5, no. 2 (2019): 1318-1327.
[10] Khean, Chang Choo, Zulkiflle Leman, Nor Mariah Adam, and Eris Elianddy Supeni. "Indoor Climates and Energy Consumption by Air Conditioning System in a Learning Resource Centre in Malaysia." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 102, no. 2 (2023): 33-41. https://doi.org/10.37934/arfmts.102.2.3341
[11] Gillingham, Kenneth, Richard G. Newell, and Karen Palmer. "Energy efficiency economics and policy." *Annual Review of Resource Economics* 1, no. 1 (2009): 597-620. https://doi.org/10.1146/annurev.resource.102308.124234
[12] Kamaruzzaman, Syahrul Nizam, and Nursyahida Zulkifli. "A review of the lighting performance in buildings through energy efficiency." In *2nd International Conference on Research in Science, Engineering and Technology (ICRSET'2014)*, pp. 165-169. 2014.
[13] Jamaludin, Roslan, Mohd Nasrun Mohd Nawi, Ahmad Yusni Bahaudin, Shahimi Mohtar, and Mohamad Zamhari Tahir. "Energy efficiency of chancellery building at Universiti Utara Malaysia." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 58, no. 2 (2019): 144-152.
[14] Amran, Mohd Effendi, Mohd Nabil Muhtazaruddin, and Habibah@Norehan Haron. "Renewable Energy Optimization Review: Variables towards Competitive Advantage in Green Building Development." *Progress in Energy and Environment* 8 (2019): 1-15.
[15] Kandt, Alicen. *Desktop Audits: Overview, Case Studies, Guidance*. No. NREL/PR-7A40-77684. National Renewable Energy Lab.(NREL), Golden, CO (United States), 2020.
[16] MS1525, D. O. M. S. "Energy efficiency and use of renewable energy for non-residential buildings-code of practice (third revision)." In *Ministry of International Trade and Industry (MITI)*. 2019.
[17] Suruhanjaya Tenaga. "National Building Energy Intensity (BEI) Labelling For Government Buildings." *Suruhanjaya Tenaga Malaysia*, 2019. https://www.st.gov.my/contents/files/download/97/20190207_Pamphlet_BEI_Labelling2.pdf.
[18] Taib, Mohamad Shafie, Mohd Faizal Mohideen Batcha, Shazarel Shamsudin, and Norashikin Sahadan. "Energy Efficiency Study in Alor Gajah Municipal Council Buildings." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 100, no. 2 (2022): 1-14. https://doi.org/10.37934/arfmts.100.2.114
[19] Aziz, Mohamad Saiful Islam, Hasbullah Harun, Ahmad Shahril Izham Ramli, Azlin Mohd Azmi, Nofri Yenita Dahlan, and Ramlan Zailani. "Energy Efficiency Initiatives for A Hospital Building in Malaysia." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 88, no. 3 (2021): 145-155. https://doi.org/10.37934/arfmts.88.3.145155
[20] Noranai, Zamri, Nurul Farahin Mohd Joharudin, Noradila Abdul Latif, Nur Liyana'Amirah Mohd Kamil, and Mohd Azahari Razali. "A Case Study on Potential Saving of Energy Consumption at Hospital Putrajaya." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 100, no. 2 (2022): 15-22. https://doi.org/10.37934/arfmts.100.2.1522