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Assessing the Energy Performance of Public University in Malaysia by using Energy Conservation Measure (ECM): A Case Study of UiTM Tapah, Malaysia

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Abstract: The growth of energy consumption in Malaysian universities has elevated national concern because it increases government annual expenditure and at the same time influence the national energy performance. In managing the energy performance of universities, it is significant to monitor the energy usage whereby areas and facilities that have the potential for energy savings can be audited in order to obtain energy-efficiency. The objective of this research is to focus on the energy performance processes conducted by identify and evaluate a various of the Energy Conservation Measure (ECM) that may contribute towards energy efficiency in the public universities. ECM has been used to acquire achievable solutions and improvement of energy consumption during the energy audit. A related information on energy audit, like electrical and mechanical systems specifications have been compiled and the use of energy have been profiled. A potential finding method used was a comparative analysis between energy implementation process before and after audit. It has been found that the significant processes in an energy audit can help to save energy consumption by comparing the energy implementation process. It is done through an investigation of energy consumption behaviour in the ECM process for the electrical and mechanical systems, and buildings activities that have an impact on energy consumption which allow energy-efficiency in a building. A case study of UiTM in Tapah Campus, Malaysia has been selected for this research since this university is among new public university in Malaysia that has higher energy users. It has been found that with the aid of ECM, this university will be able to achieve 135 kWh/m2/year of Building Energy Index (BEI). Eight (8) improvement strategies in ECMs have been suggested that significantly achieve the energy performance efficiency, involving eight (8) strategies, which are four (4) No-Cost Measures, two (2) Medium-Cost Measures and two (2) High-Cost Measures.

Keywords: Energy consumption, Energy Conservation Measure (ECM), energy audit, energy performance, university

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1. Introduction

Energy consumption in Malaysia has increased over the past twenty years (2000-2020), with the electricity consumption in Peninsular Malaysia has risen from 94,666 GWh in 2010 to 108,529 GWh in 2017 (Energy Commission, 2020). Malaysian utility company, Tenaga Nasional Berhad has reported that there will be a definite surge in the demand for energy in Malaysia, particularly in the electricity sector by approximately 13% by year 2020 to 2025 (Tenaga Nasional Berhad, 2022).

The growing trends of energy consumption in Malaysia happens due to national rapid development and the accumulate effort of all industries; like transportation, heavy industries, maritime, construction and manufacturing, which are crucial for economic growth of Malaysia (Malaysia Productivity Corporation, 2022). As the population grows the demand for electricity also increased. Therefore, the energy sector needs to make a priority towards the efficiency effort and the goal is to apply less energy consumption for buildings, whilst achieving the same level of works without increasing the carbon emissions (Energy Commission, 2020).

According to Elshamy (2015), retail and services buildings consume the most of energy of all the commercial buildings which is 20%, office buildings (19%) and educational buildings consume 11% more energy than all hospitals or other medical buildings. For educational buildings, it includes the university buildings. At the moment, there are 20 public universities, 50 private universities and 34 private university colleges in Malaysia (Ministry of Higher Education Malaysia, 2022) and this increasing numbers have contributed to the issue of energy demand from universities' users. Wen and Palanichamy (2018) has highlighted, that most of Malaysian universities consume high energy due to the population within each university and this scenario will impose a huge amount of electricity cost to the universities. In one of the reports by Latif et al., (2019), RM 2.7 billion must be paid every year by the Government for electricity consumption for universities. It is identified that the university buildings in Malaysia used high energy consumption where 2/3 of this energy is used for cooling, water heater, and mechanical ventilation and 1/3 is used for lighting and other electrical appliances (Dzulkefli, 2020, Abd-Razak, et al, 2013).

Therefore, it is necessary to suggest different efforts and policies to assist the universities in achieving energy efficiency performance (Rebelatto, et al., 2020). Government of Malaysia, in the Economic Transformation Program (ETP) (Malaysia, 2015) has decided that reduction in electricity consumption as one of the Key Performance Indicators (KPIs) (National Key Result Area, NKRA) for all ministries including the Ministry of Higher Education (Government Transformation Programme, 2010). In addition, the National Energy Efficiency Action Plan (NEEAP) (2015) which has been suggested by the Malaysian Energy, Green Technology and Water, in 2015 is to allow a more effective initiative to overcome various energy efficiency obstacles (KeTTHA, 2015). The NEEAP aims to cut consumption through a 6% reduction in electricity demand and save 50,594 GWh in 10-year period (KeTTHA, 2015). Under the recent national energy-efficiency implementation, the Malaysian Energy Commission has initiated various energy-efficiency blueprints, programs, and policies (EC, 2019), as listed in Table 1.

Table 1 - Energy-efficiency efforts made by the Government of Malaysia (Energy Commission, 2019)

Efforts	Year Implemented (Targeted/Has been Implemented)
"Putrajaya Green City"	2025
"Low-Carbon Society Blueprint"	2025
The Peninsular Malaysia LED Street Lighting Conversion (2018 – 2020)	2020
Smart Meter Program	2018-2025
The Renewable Energy Transition	2019=2025

Most of these efforts listed in Table 1 were derived under the 12th Malaysian Plan by the Energy Commission (EC, 2019), whereby introducing an Incentive-Based Regulation initiative (EC, 2020) has helped to push many associated energy-efficiency efforts in the country. The largest scale of national energy effort is by replacing 60% of public streetlights in Peninsular Malaysia with 90-watt Light Emitting Diode (LED) bulbs (TNB, 2019), which also covers many streetlights in public universities in Malaysia.

2. Background of Study

Electricity tariff in Malaysia has a long phase of hike, from 2006 to 2023. TNB (2019) has mentioned that since June 2006, the hike of electricity tariff for Peninsular Malaysia has a dominant influence on the operating cost for building sector, including universities by 12%. It is recorded that the average tariff for 2011 is RM0.325sen/kWh and in 2015, the average tariff is increase to RM0.395sen/kWh (Energy Commission (2020). In 2014, the electricity tariff has been raised for 0.2% by TNB (Tenaga Nasional Berhad, 2019) which has affected monthly bill expenditure of many public universities (Dzulkefli, 2020). In recent announcement made by the Malaysian Prime Minister, the government announced that medium voltage and high voltage users, including multinational companies, will be charged a surcharge of 20 sen per kWh for the period of Jan 1 to June 30, 2023 (NST, 2022).

The growth in electricity prices has influence maintenance management sector to put focus on energy efficiency and conservation as the significant operational tool, including universities (Dzulkefli, 2020). To establish energy efficiency, the university needs to perform an energy audit as a first step. Under the 11th Malaysia Plan, the Energy Efficiency Projects (2016-2020) has been introduced for all buildings in Malaysia, in providing an energy audit conditional grant in performing compulsory energy audit regulations required by the Malaysian Energy Commission (2020).

2.1 Energy Legislation

According to the report produced by the United Nations Development Programme (UNDP) on Malaysia's Building Sector Energy Efficiency Project (BSEEP) in 2017, the electricity demand is forecasted to achieve 18,947 MW in 2020 and 23,092 MW in 2030 (UNDP, 2017) which was higher than expected, at a rate of approximately 35%. The BSEEP aims to improve "energy utilization efficiency in Malaysia buildings, especially those in the commercial and government sectors, by promoting the energy conservation design of new buildings and enhancing the energy utilization efficiency in the operation of existing buildings" (UNDP, 2017). Existing government policies and legislation have been improvised in dealing with the energy efficiency in buildings and efforts to incorporate into the new Malaysian Standard MS 1525:2019 (under the Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings legislation) (SEDA, 2015). It is evident that the building industry in Malaysia needs to develop and enforce energy efficiency or energy performance standards (Zaid & Graham, 2017), which also cover public universities. In 2020, the Malaysia Energy Commission has also proposed the Energy Efficiency and Conservation Act (EECA) in order to comply with Building Energy Index (BEI) requirements which may accelerate EE initiatives and implementation to reach the target to reduce 8% of electricity consumption (EC, 2020).

2.2 Energy Target for the Malaysian Universities

The Ministry of Education (MOE) and the Ministry of Higher Education (MOHE) in Malaysia has encouraged all educational institutions; namely schools and universities to conserve energy by empowering energy programs, such as energy audit, campaign and monitoring (Ministry of Higher Education Malaysia, 2022). This has pushed every operational stakeholder to put efforts in implementing energy saving programs in the buildings. This is in conjunction with the aim made by the Ministry of Energy, Green Technology and Water Malaysia in 2017 which to promotes an energy conservation scheme to all buildings to decrease electricity consumption by 10% (KeTTHA, 2017). With a strategic energy approach, a university can save approximately 20% of the electricity bill which usually constitutes about 5 % of the overall expenditure of a building's operation (Dzulkefli, 2020). Usually, the waste of electricity in universities comes from the building users that have lack of awareness, exposure, and knowledge on energy saving (Zaid & Graham, 2017; Zakaria, et al, 2016).

2.3 Energy Issues in the Malaysian Universities

Many types of building users in universities (like students, lecturers, academic staffs and operational staffs) that uses studying equipment, machineries in lab and other related facilities in universities in comparison to other types of building. Dzulkefli (2020) has highlighted that it is estimated that the general electricity bill for universities expenditure in Malaysia is increasing between 1% - 5% every year. Lack of high energy-efficient technologies due to budget constraint and less awareness from the building users led to the issue of wastage in energy consumption (Latif, et. Al, 2019). Artificial lighting and air-conditioning system are also a major issue of energy consumption in the universities (Dzulkefli, 2020). For the air-conditioning system, it is due to substantial increases of heat of the tropic region that also affects the cooling loads for air-conditioners (Latif, et. Al, 2019; Dzulkefli, 2020). For lighting, the energy consumption recorded between 10% to 30% of building electricity consumption in university buildings due to uncontrollable usage of artificial lighting even during daytime (Wan Abdullah, et al., 2022). This is one of the important reasons on the significance of conducting energy audit to promote energy efficiency and energy saving in buildings. In general, these universities had to withstand with a heavy operational and maintenance cost to meet the energy demand from the users. The overall consumption of energy will increase annually and with limited implementation on energy audit, the energy performance will be declined, and energy waste cannot be controlled.

2.4 The Energy Conservation Measure (ECM)

An Energy Conservation Measure (ECM) is the strategy involving various technological resource applied to improve the energy performance of a building (Costa, et al, 2020). The function of ECM is to minimize the energy used in a building with the aid of a particular technology, process, or application. ECM is one of the solutions that is derived after the energy audit process. With strategic measure, like ECM, there is potential to save 5% to 10% of the energy expenditure by improving the energy performance (Bernardo & Oliveira, 2018).

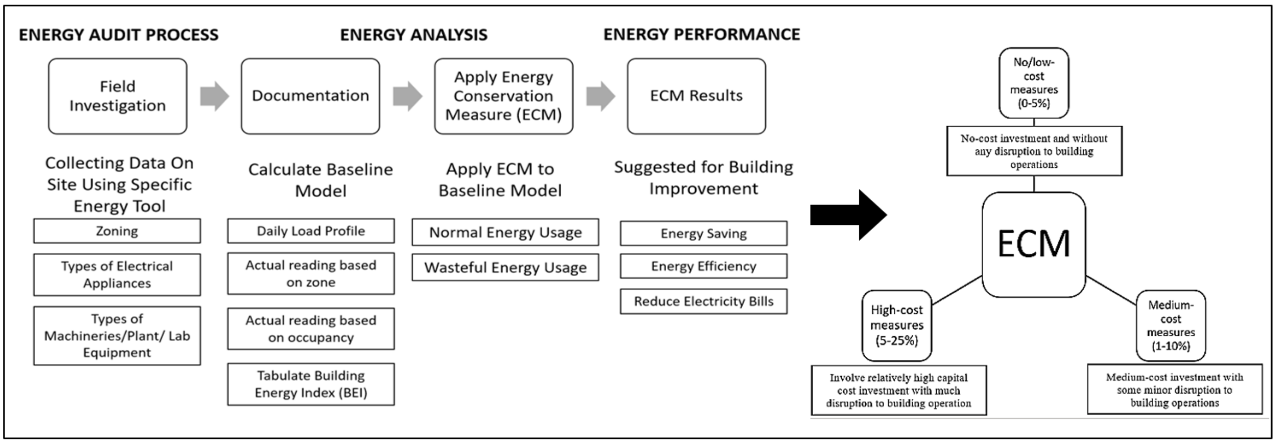


Fig. 1 - The process of Energy Conservation Measure (ECM) (constructed by the Author)

This Figure 1 shows the significant of energy audit and how ECM can help the management of the university to improve the energy performance and ultimately, reduce the electricity bills. At the moment, there is lack of thorough ECM implementation in Malaysian universities (Dzulkefli, 2020) due to budget constraint and lack of engagement from the top management and entire employees (Wen and Palanichamy, 2018). ECM can be divided into 3 categories, (i) No/low-cost measures, (ii) Medium-cost measures and (iii) High-cost measures (Energy Commission, 2020).

3. The Case Study

UiTM Tapah Campus is in Perak, Malaysia, and among the largest university in the Northern region of Peninsular Malaysia. It is a 3-hours' drive from Kuala Lumpur and 1 hour-drive from Ipoh, the capital city of Perak.

Fig. 2 - UiTM Tapah Campus in Perak (a) satellite-view; (b) the case study

This university has 48 buildings with a gross building floor area of 82,848.00 square meters and net floor area of 42,136.00 square meters (UiTM Perak, 2023) (See Figure 2).

3.1 The Campus Information

The whole population of this campus is up to 4,000 students and 1,000 staffs, with the total of highest electricity usage for the whole campus is about 8 working hours, from 8 am until 5 pm and after working hours (from 5 pm to 7 am) due to hostel occupancy during night time. The information on the total GFA is significant during the preliminary energy audit in identifying the space because it may affect the building user's energy trend.

Table 2 - List of buildings in the campus with Gross Floor Area/GFA (m2)

Buildings	Gross Floor Area (GFA)(±m²)
Administration	3,684.53
Library	5,509.27
Student Centre & Cafeteria	3,701.70
Lecturer A, B & C	4,968.64

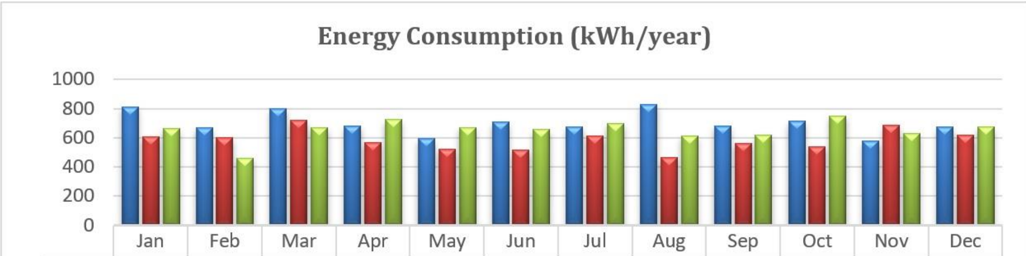
Lecture Hall (DK 1,2)	812.72
Lecture Hall (DK 3,4)	702.60
Faculty of Accounting A (AK1)	2,442.99
Faculty of Accounting B (AK 2)	2,529.47
Faculty of Computer Science & Mathematic (AK 3)	2,561.43
Faculty of Applied Science B (AK 4)	5,360.01
Faculty of Applied Science A (AK 5)	6,159.05
Special Gas Room	18.58
Farm Management Office	611.46
Islamic Centre	819.51
Health Unit	497.96
Maintenance & Security Unit	1,020.49
Alpha Food court	1,076.89
Beta Food court	1,076.89
Admin Cafeteria	369.60
Multipurpose Hall	291.84
Auxiliary Police	14.28
Student Accommodation A	8224.05
Student Accommodation A1	3973.64
Student Accommodation B	16,661.57
Student Accommodation C	1,228.17
Student Accommodation D	2320.02
Student Accommodation E	1,258.52
Student Laundry	152.00
Plant House 1	4,013.80
Plant House 2	183.61
Plant House 3	204.35
Plant House 4	204.35
Waste House	239.88
TOTAL GFA (m²)	**82,848.00**

The list of buildings in the campus is listed with the overall gross floor area (GFA) in Table 2. The electrical appliances used in each building and to depict the total demand and actual energy consumption for the whole buildings in UiTM Tapah Campus is also based on GFA of the building.

3.2 The Energy Information and Load Profile

The energy supplier for this case study is Tenaga Nasional Berhad (TNB). Based on the Tenaga Nasional Berhad (TNB) tariff of the Medium Voltage Peak/Off-Peak Commercial Tariff category (TNB, 2014), this university is categorized under C2: Education tariff, and the university would be charged for RM 0.45/kWh for the first 100 kWh/month, RM 0.365/kWh for the next 4900 kWh, RM 0.30/kWh for any additional kWh/month and RM 0.22/kWh for off-peak period (TNB, 2019). The university is linked to the 11kV electricity incoming supply from the TNB Transmission Main Intake (TMI) and supply directly from the underground cable to Plant House 1. There is also a 3-generator total of 450MW used for backup supply during emergency or blackout purposes. Every building in UiTM Tapah Campus has own power meter which allows actual data to be collected during the operation hours.

Year	Annual Energy Consumption (kWh)	Annual Bill Cost (RM)/(USD)
Year 1 (2020)	8,423,574.00	3,232,901.56/697798.74
Year 2 (2021)	7,243,004.00	2,984,189.93/644116.11
Year 3 (2022)	7,841,416.00	3,116,892.39/672758.99



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2020	813	672	800	681	594	707	677	830	683	714	577	674
2021	609	600	720	570	522	514	615	463	563	541	685	616
2022	664	462	672	724	672	657	699	613	621	750	629	673

Fig. 3 - The annual energy consumption data (for 3 years) for UiTM Tapah Campus

Figure 3 represents their annual energy consumption data (for 3 years) with the actual data from the electricity bills.

Table 3 - List of buildings in the campus with Gross Floor Area/GFA (m2)

Types of Appliances	Equipment	Total Power (kW)
Air-Conditioning System	Chiller and Pump	1,284
	ACSU, AHU, FCU, PACU and VRV	536
Lab Equipment	Freezer, Oven, Incubator, Centrifuge, Autoclave	603
Office and Classroom Equipment	PCs, Printer, Photocopier, TVs, Projectors	225
Lighting System		602

From Table 3, the highest energy reading for Year 1 is in August with 830,490 kWh and the lowest usage is in November with 577,383 kWh. The highest energy reading Year 2 is in November with 742,598 kWh whilst the lowest reading is in August with 499,861 kWh. The highest energy reading in Year 3 is in October with 750,365 kWh and the lowest is in February with 462,197 kWh. Table 3 shows the significant electrical applications in the campus that have contributed towards the power consumption.

A daily load profile for UiTM Tapah Campus has been compiled and a typical daily load profile (for 24-hours period) is shown in Figure 4**.**

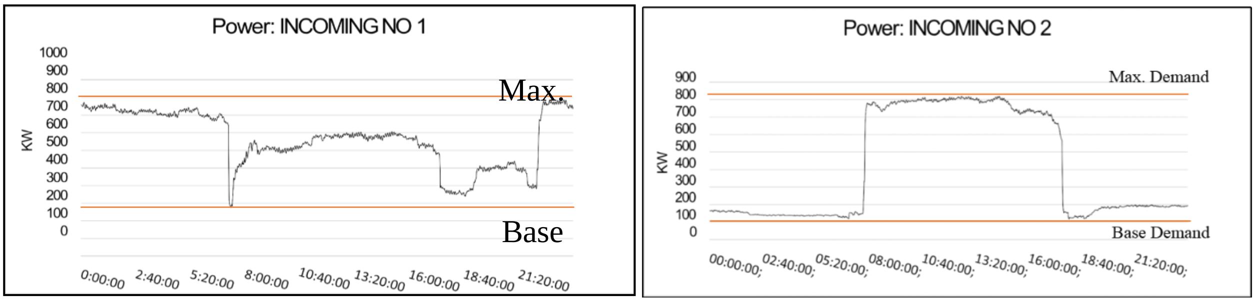


Fig. 4 - A daily load profile from incoming supply to plant house (a) Plant No 1; and (b) Plant No 2

Figure 4 demonstrate that at Main Incoming for Plant No.1, the maximum power demand is at 750kW, and the base demand is approximately at 150kW, whilst at the Main Incoming for Plant No.2, the maximum power demand is at 800kW and the base demand is at 100kW. It is noticeable that the highest demand occurs from 8 am to 5 pm which may be due to the operation of office hours.

4. Results and Discussion

For data collection, the demand for average power consumption for UiTM Tapah Campus was recorded using a clamp meter at the Low Voltage Room. It is collected at the Main Switch Board (MSB), Sub-Switch Board (SSB) and Distribution Board (DB) and the clamp meter has been used to record the current data in Ampere unit. By using the Power Law Equation (P=IV cos □), the current data has been converted to get a power consumption (kW) data which involved the electricity demand from the end user collected at a certain time. It is assumed that the predicted profile is basically within the 2 hours interval since most of the lecture halls and classrooms were usually occupied for the 2 hours lectures.

4.1 Energy Analysis

Data has been collected and compiled from various buildings in UiTM Tapah campus, namely, (i) Administrative block, (ii) Lecturer's A, B and C blocks, (iii) Library block, (iv) Health Unit block, (v) Islamic Centre, (vi) Student Centre, (vii) faculties' buildings at AK1, AK2, AK3, AK4, AK5, (viii) lecture halls at DK1, DK2, DK3 and DK4 and (x) students' accommodations at UPK (See also Table 2). The load profile represents typical electricity demand in the campus, including all lighting systems, whereby the demand increases starting from 6 am for all buildings, peak time is from 8 am until 4 pm and the reduced demand is visibly shown after 5 p.m. The electricity trends transform gradually due to office hours from 8 am to 5 pm. This is shown in Figure 5.

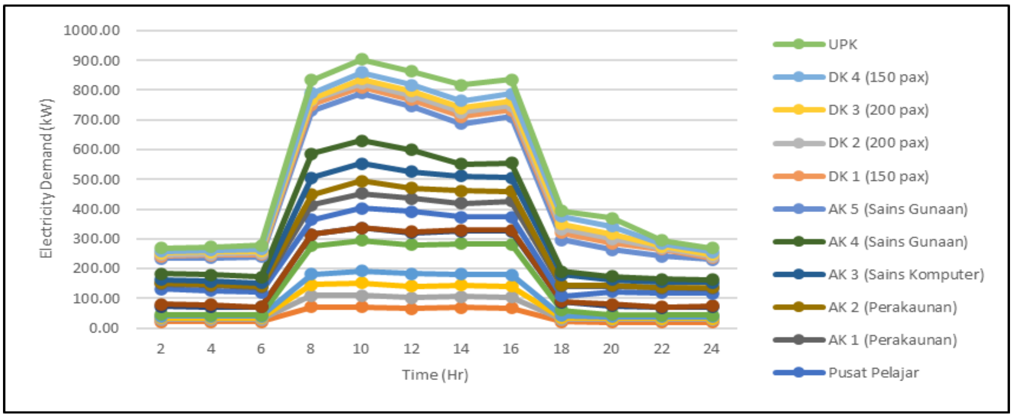


Fig. 5 - The electricity demand in UiTM Tapah

Figure 5 represents the data by using clamp meter during an energy audit based on overall energy usage for 24-hours. However, in determining the highest energy performance used in each space, a comparison ratio between the energy data and the GFA have been calculated by using Building Energy Index (BEI) formula. It measures the total energy used in a building for one year in kilowatts hours (kWh) divided by the gross floor area of the building in square meters (MS 1525:2014).

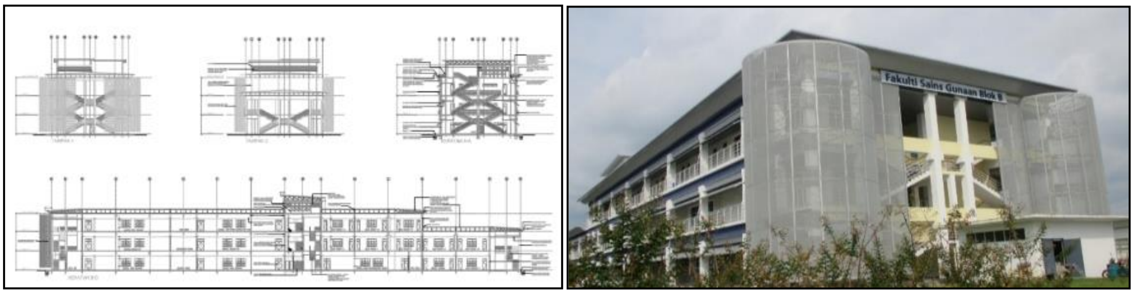


Fig. 6 - Block of AK5 (a) schematic drawing and; (b) the front façade of AK 5 block

A power data logger has been used to get the daily energy consumption for this block (see Figure 6).

Table 4 - Electricity demand in UiTM Tapah Campus based on GFA/kWh for every 2 hours

No	Building	Electricity Demand (kW)											
		2	4	6	8	10	12	14	16	18	20	22	24
1	Administrative	20.92	20.83	20.79	69.97	70.67	64.49	69.47	67.35	20.54	20.29	20.29	19.84
2	Lecturer A	7.55	7.43	7.22	39.22	38.84	38.06	36.11	35.69	8.22	7.8	7.72	8.09
3	Lecturer B	5.81	5.6	5.56	36.06	41.17	38.18	37.68	37.85	6.02	4.9	4.86	4.81
4	Lecturer C	4.94	4.94	5.15	36.06	41.17	42.33	37.68	37.85	6.02	4.98	4.86	4.61
5	Library	5.8	5.19	4.92	95.01	102.69	96.94	103.15	103.51	18.95	7.84	5.08	5.94
6	Health Unit	27.98	27.08	27.19	38.6	41.35	40.88	41.77	43.06	27.66	27.98	27.08	27.62
7	Islamic Centre	6.79	6.84	0.44	0.39	1.53	2.56	3.89	3.75	1.58	6.41	0.5	2.78
8	Student Centre	51.57	48.59	49.78	48.14	65.66	68.24	42.84	44.86	19.22	42.67	47.35	42.66
9	AK 1	15.96	16.31	16.31	50.5	49.96	43.48	47.33	52.09	31.58	16.74	16.4	16.69
10	AK 2	3.4	3.92	3.72	34.03	41.35	35.72	40.93	33.79	3.79	3.85	3.52	3.91
11	AK 3	11.12	10.96	10.02	58.12	58	54.89	49.24	45.37	35.24	19.28	16.74	15.77
12	AK 4	20.35	20.53	20.51	80.72	78.31	73.61	41.89	50.14	10.79	11.2	9.5	9.56
13	AK 5	51.73	58.46	67.15	143.6	158.45	146.66	135.79	154.96	106.97	88.62	77.64	67.52
14	DK 1	7.88	7.79	8.22	20.45	21.47	21.33	23.09	22.78	23.09	22.84	22.77	6.83
15	DK 2	4.83	4.88	4.97	14.18	12.91	12.79	14.83	15.22	13.69	15.45	4.3	4.3
16	DK 3	5.91	6.17	6.33	5.03	14.6	17.58	14.79	15.83	16.22	15.91	6.22	6.35
17	DK 4	6.22	6.24	6.78	19.43	20.76	19.62	23.54	23.98	25.42	24.73	9.05	8.32

Table 4 shows the result after BEI formula has been calculated for data in Figure 5 and in Table 2. Table 4 shows the highest energy demand based on the GFA is at AK 5 building or Faculty of Applied Science. With the GFA of 6,159.05 m2, AK5 building recorded the energy demand between the lowest readings of 51.73 kWh and the highest readings 158.45 kWh in comparison with other buildings that have larger area. This is because AK5 consist of many laboratories and high power-rated laboratories equipment. The second highest energy consumption is the library and followed by AK4 block and the Student Centre.

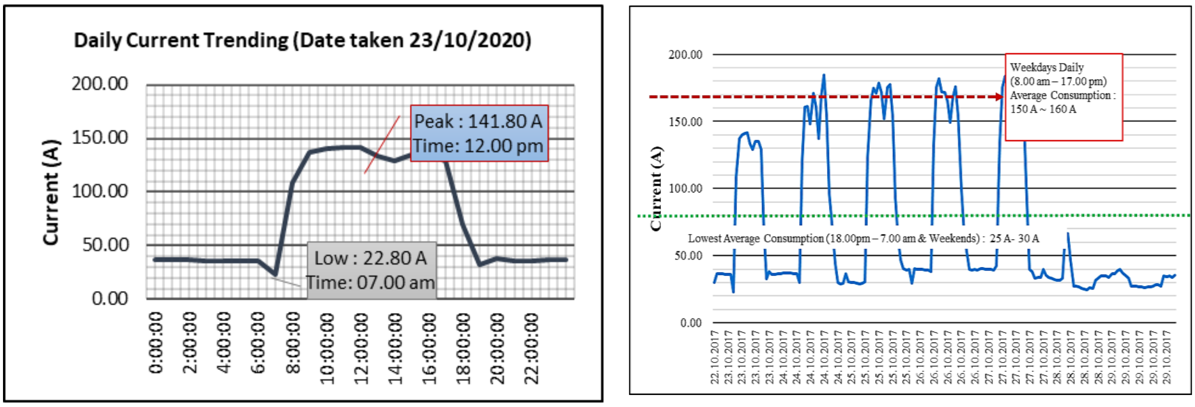


Fig. 7 - The example of data recorded using a power data logger: (a) daily and; (b) 7- days

The daily current trending has been recorded for single days and 7-days (see Figure 7). Figures 7 shows the data recorded for daily and 7-days trend, respectively. However, the baseline of the building shows the average of 25 A current occurs during off-peak hours. It is supposed to be lower than 25 A current since there are no activities in the building during night-time. Therefore, the ECM has been focused on the baseline of the building, to identify the occurrence of the current of 25 A to 30 A during night-time and weekend.

4.2 Assessing Energy Conservation Measures (ECM)

AK5 block has been selected to improve its energy consumption pattern with the approach of the Energy Conservation Measure (ECM) due to its high energy consumption. The process involved; (i) identifying major factors affecting energy consumption and (ii) highlighting the most effective approach or technologies for reducing the energy consumption based on three (3) categories of ECM (see Figure 1). It also involved ECM equations, as listed below (Electrical Energy Audit Guidelines for Building by Energy Commission, 2022):

a) Power Consumption (kW) = Quantity of unit x Wattage of electrical system (W)
b) Energy Consumption (kWh) = Power (kW) x Hour usage (H)
c) Bill Payment (RM) = Energy Consumption (kWh) x RM 0.366 (on-peak hour)

d) Bill Payment (RM) = Energy Consumption (kWh) x RM 0.224 (off-peak hour)

Table 5 - The output from the proposed ECM Approach

During Energy Audit and Energy Analysis			**Energy Conservation Measures (ECM)**			
No	**Identifying Key Issues**	**Suggested Energy Saving Solution**	No/low-cost measures	Medium-cost measures	High-cost measures	Potential Saving (Monthly)
1	In the staff rooms: lighting and personal computer are not switch off during lunch hour	1. Awareness program (sticker, social media and e-flyer on energy saving awareness). 2. Monitoring walk-through by officers during lunch hour	(i) Peak Shaving - Switch off light during lunch hour for 2 hours or when room not in use (ii) Shut-off the PC during lunch hour for 2 hours and after finish working hour	Not suitable	Not suitable	(i) 2,500 kWh, (ii)24,750 kWh
2	Unoccupied classroom: air-conditioning switches on from 8 am until 5 pm	Reschedule the Building Management System (BMS) by following each class timetable only	Rescheduling air-conditioning system by using a Building Management System (BMS)	Not suitable	Not suitable	11,492 kWh
3	Outdoor or decorative lightings are switch on during night-time	Switch off all decorative lights and only switch it on during special events	Peak Shaving - Switch OFF decorative outdoor lightings	Not suitable	Not suitable	15,900 kWh
4	Lighting system: Still use fluorescent T5 light	Replace fluorescent to LED lighting	Not suitable	Replace existing fluorescent light T8 and T5 to LED light type in the buildings	Not suitable	53,920 kWh
5	Lighting system at corridor or toilet: always switch on during daytime	Reminder or install timer or motion sensor	Not suitable	Install motion sensor at location such as lobby, toilet or corridor	Not suitable	4,870 kWh
6	Air-conditioning systems such as FCU motors running in full load	Install Variable Speed Drive (VSD) to reduce load and control the speed	Not suitable	Not suitable	(i)Variable Speed Drive (VSD) install at Air Handling Unit (AHU), (ii)Variable Speed Drive (VSD) install at Fan Coil Unit (FCU)	(i)16,322.48 kWh, (ii)13,616.59 kWh

Table 5 has tabulated the suitable categories of costing measures for each issue and solution suggested.

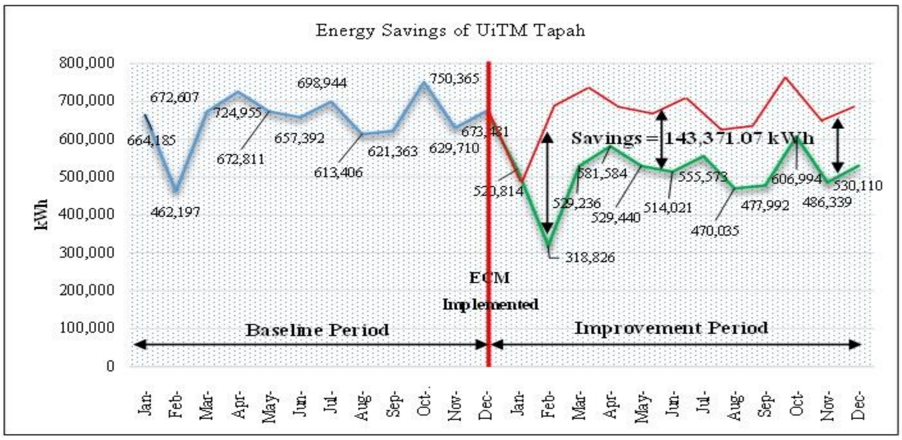


Fig. 8 - The baseline period vs the ECM improvement period of UiTM Tapah Campus

The ECM graph in Figure 8 demonstrates the prospective improvement for UiTM Tapah Campus within baseline period vs improvement period. Baseline period is a baseline energy use before the ECM approach and the improvement period is a baseline energy use pattern after the ECM approach. Figure 8 also shows from the graph that a saving of 143,371.07 kWh can be achieved after all ECMs has been applied to this building.

These suggestions have been based on the most economic condition suggested by the top management of the university. From the energy audit outcome, it is found that the university can accomplish a good energy conservation measure by:

(i) Planning of energy usage - Implementing a proper planning for the use of air-conditioning system in the lecture theatre or classes - The peak demand is from 8 am to 12 pm and 2 pm to 5 pm, and the energy operation is in full use during this period. Therefore, cutting down a portion of the energy load during the low demand period (from 12 pm to 2 pm, and after 5 pm) will subsequently lessen the load factor of the campus. Thus, the two peaks of load demand are lessened accordingly, with the aid from the existing Building Management System (BMS). Hence, the energy consumption can be saved about 11,492 kWh.

(ii) Peak Shaving – A strategy for avoiding peak demand by reducing power consumption during a demand interval. In UiTM Tapah cases, peak shaving can be accomplished by switching off PCs, electrical equipment and lighting system in the lecturers' room, offices, corridor and toilets. This can also be accomplished by installing motion sensor and timer at corridor areas and toilets.

(iii) Minimizing demand load and charges - By analysing consumption patterns, existing fluorescent lighting can be replaced with LED lighting and new Variable Speed Drive (VSD) can be installed at current AHU and FCU in order to increase the operational efficiency. Thus, the energy consumption can be saved more than 100,00 kWh per month.

5. Conclusion

This research has provided a comprehensive investigation on applying the Energy Conservation Measures (ECM) for the case study which utilised energy profile data and the Gross Floor Area (GFA) information. By systematically analysing the energy usage of each building in the campus and identifying key issues, the research enables an understanding of the significant solutions involved in accessing the energy performance. It proves that the public universities in Malaysia should invest more in latest energy-efficient technologies in order to optimize energy performance. Accordingly, the energy managers in universities should strategize the energy audit to ensure optimal and efficient energy use. Energy audit is the most important part of an energy management program where it shows the actual profile of energy trend of the associated systems and solutions for remedial energy conservation measures. This will help to reduce energy waste areas with well-defined economic implications. Therefore, it is wise to have the energy audit implementation for public universities in Malaysia so that the energy can be used efficiently, and unnecessary waste of energy can be prevented. As a conclusion, UiTM Tapah needs to look into the suggested energy conservation measures (ECM) in order to achieve the energy performance.

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