Journal of Advanced Research in Applied Sciences and Engineering Technology 34, Issue 2 (2024) 195-209

SEMARAK ILMU PUBLISHING

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

Energy Profiling and Potential Energy Saving of a Keropok Lekor Small Industry

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ARTICLE INFO

Article history:
Received 23 June 2023
Received in revised form 6 November 2023
Accepted 20 November 2023
Available online 7 December 2023

Keywords:
Small industry; energy audit; energy profiling; energy saving; energy efficiency

ABSTRACT

Malaysia Statistical Business Register (MSBR) released by the Department of Statistics Malaysia (DOSM) highlighted that the total number of SMEs in Malaysia was 97.2% of the total business establishment in 2020. Keropok lekor is a favourite snack in Malaysia and this small industry blossomed in the area near the ocean fishing industry. This study aimed to conduct an energy profiling study to identify the energy consumption profile, electricity usage analysis, and propose cost-benefit energy conservation measures (ECMs) for a selected keropok lekor small industry in Terengganu, Malaysia. The energy audit starts with a preliminary energy usage analysis by reviewing three years of electricity bills from 2019 to 2021. Then, the field data collection was conducted by measuring the illuminance level, air velocity, and air temperature at the shop area and two manufacturing (manufacturing 1 and 2) spaces. Results of the analysis showed that the freezers and chillers consumed the highest 71.3% of overall electrical usage. Applicable Energy Counter Measures (ECMs) were proposed to the small industry management from no cost to high-cost investment such as energy-saving training programs for the workers, organized and efficient usage of the freezers and chillers, replacing electrical appliances with efficient-energy appliances, retrofitting LED lamps, and installation of solar panels. The cost analysis showed 0.73 years of the pay-back period for LED tubes retrofitting and 6 years for solar panel installation. Overall, the energy profiling study was successfully conducted and applicable ECMs with cost-benefit analysis were also had been proposed to the small industry for effective energy management.

1. Introduction

According to the Malaysia Statistical Business Register (MSBR) released by the Department of Statistics Malaysia (DOSM), the total number of small and medium enterprises (SMEs) in Malaysia was 97.4% of the total business establishment in 2021 [1]. The small manufacturing industry in Malaysia is defined as an industry with an annual sales turnover from MYR 300,000 to less than MYR

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https://doi.org/10.37934/araset.34.2.195209

15 million or, the number of full-time employees is from 5 to less than 75 [2]. Small industries do not have the resources to select suitable technologies or create the right strategy for Industry 4.0 [3]. The small industry usually started up from home-based/micro businesses and expanded into a small industry with limited resources. Small businesses are primarily found in geographic clusters, and many of them require a lot of energy. The effective use of energy, a crucial input in their functions, is necessary for their survival and growth [4].

Malaysia Energy Commission (2020) statistics until 2017 showed that Malaysia is the third highest final energy consumption per capita in ASEAN after Singapore and Brunei [5]. There are three factors outlined related to building energy consumption which are natural, social, and human behavior [6]. The industrial sector continues to consume the most energy, while the building sector's energy has dramatically expanded over the past few decades because of diverse building functions, and global climate change [7]. Technological evolution in energy systems is of the essence and inevitable factor that researchers need to deal with since energy resources are also a highly important form of political and economic perspective [8]. The surge of population growth and economic development over the years has led to the increase of energy usage within Malaysia. Hence, comprehensive strategic planning is needed to ensure the future energy security of Malaysia. In this case, the government has consistently amended the energy policy in parallel to the needs of the country's development [9]. Malaysia had published the Malaysian Standard MS 1525 which gives guidance on the efficient use of energy including the application of renewable energy in new and existing non-residential buildings. It focuses on architectural and passive design strategy, building envelopes, efficient air conditioning and lighting, energy management system, and building energy performance [10].

Several studies related to SMEs and energy efficiency have been conducted in other countries [11-15]. There were barriers and challenges identified in designing and delivering energy efficiency in SMEs which include poor existing energy policy, financial, economic, behavioral, and personal barrier [16-18]. Malaysia is fully committed to being a key part of the global transition to a low-carbon, and eventually carbon-neutral society, with ambitions of achieving this by 2050 [19]. Since SMEs are the largest group of businesses in Malaysia, they linearly contributed to the overall Malaysian energy consumption. Thus, there is an urgent need to investigate the energy usage profiling of these SMEs and to look and the saving potential that can be proposed to the SMEs management. This study aims to investigate the energy profiling and energy-saving potential of a keropok lekor small industry located in Kemaman, Terengganu as a case study. The output of the study benefited the small industry management for their short-term and long-term planning to reduce energy consumption and efficient energy management.

2. Background of Study

Keropok lekor is one of the favorite snacks in Malaysia. It is made from fish mixed with starch flour and shaped into long, sausage-like shapes before being boiled for several hours. Keropok lekor is cut into pieces and fried with cooking oil and it is typically served hot with a hot chili dipping sauce. Keropok lekor industry blossomed in the area near the ocean fishing industry where an abundant supply of fish can be easily assessed. Some of these businesses were expanding as results of assistance provided by Department of Fisheries Malaysia in terms of technology and machineries [20]. Figure 1 shows the boiled keropok lekor.

Fig. 1. Boiled keropok lekor

The study was conducted in one of the keropok lekor small industries located in Kemaman, Terengganu which is located on the eastern coast of Peninsular Malaysia. This small manufacturing industry also has a shop area where they directly sell their products. They sell freshly boiled keropok lekor, frozen vacuum-packed keropok lekor, and fish crackers as shown in Figure 2. The manufacturing is divided into two spaces; manufacturing space 1 and manufacturing space 2 as shown in Figure 3 and Figure 4. Manufacturing space 1 is where the fish are prepared before grinding and mixing process with starch flour using industrial mixer. Manufacturing space 2 is where the mixture of fish and starch flour is molded into a sausage shape and boiled. The keropok lekor are also vacuum packed and stored in the freezers and chillers.

Fig. 2. Shop area

Fig. 3. Manufacturing space 1

Fig. 4. Manufacturing space 2

This small manufacturing industry has 8 workers and operated continuously from 8.00 am to 6.00 pm daily with a total of ten hours daily and seventy hours weekly of normal operation time. The electrical consumption was mostly used by the chillers and freezers, lighting system, fans, and pieces of machinery such as ice-crusher, grinder, mixer, sealer, and vacuum packer.

3. Methodology

The energy profiling was conducted in a few stages starting with preliminary energy usage analysis, field data collection, end-use load apportioning identification, and shortlisting of the applicable energy conservation measures (ECMs).

3.1 Preliminary Energy Usage

The first step was to conduct a preliminary energy usage analysis. Information such as the building's gross floor area and the building's primary usage was observed and determined. Utility bills starting from the year 2019 to 2021 were sorted, assembled, and reviewed to investigate the building's energy performance to find the patterns of energy usage and to identify any irregularities during the investigated period.

To help SME business to recover their business, Malaysia's government have introduced Economic Stimulus Package / Pakej Ransangan Ekonomi Prihatin Rakyat (PRIHATIN) in 2020 and PEMULIH Aid Package / Pakej Perlindungan Rakyat dan Pemulihan Ekonomi (PEMULIH) in 2021 with 2% and 5% electricity bill discount respectively. With this help, SMEs were able to sustain their business. The discount given has affected the electricity cost. Therefore, even though the electricity consumption was high, the cost will be lower due to the discount given together with the imbalance cost pass-through (ICPT) rebate starting from 1 January until 31 December 2021. The rebate was granted due to a reduction in actual fuel costs from July to December 2020, which was commensurate with a decrease in actual coal and gas prices for the power sector. The investigated small industry energy consumption used tariff B for energy consumption and the formulation and charges rate for the shop area and manufacturing spaces are shown in Table 1 for 2019 and, Table 2 for the years 2020 and 2021.

Table 1
Formulation of tariff B (low voltage commercial) for 2019

Components	Charges Rate	Formula
Energy Consumption (EC)	First 200 kWh per month (RM 0.4350/kWh)	A = RM 0.4350/kWh x EC
	Next kWh (201 kWh onwards) (RM 0.509/kWh)	B = RM 0.509/kWh x (EC-200)
Imbalance Cost Pass Through (ICPT)	(RM 0.0152/kWh)* (RM 0.0135/kWh)** (RM 0.0255/kWh)***	C = RM 0.0152 x EC Note: The coefficient value for ICPT is subjected to the enforcement date.
Good and Services Tax (GST)	6%	D = 6% x (A + B + C) Note: Subjected to energy usage only before 1st June 2018
Renewable Energy Fund (KWTBB)	1.6%	E = 1.6% x (A + B)
Late Payment Penalty Charge	1%	F = (Outstanding Amount) x 1% x (No. of Days Outstanding / 30 days) Note: Imposed if payment of electricity bills is made later than 30 days after the bill date
Power Factor Surcharge	1.5% surcharge (for every 0.01 less than 0.85 power factor) 3% surcharge (for every 0.01 less than 0.75 power factor)	G = [(0.85 – 0.75) / 0.01 x 1.5% x EC (RM)] + [(0.75 – pf) / 0.01 x 3% x EC (RM)]
Total Electricity Cost		Total = A + B + C + D + E + F + G

*Enforcement date: 1/1/2016, **Enforcement date: 1/7/2018, ***Enforcement date: 1/3/2019

Table 2
Formulation of tariff B (low voltage commercial) for 2020 and 2021

Components	Charges Rate	Formula
Energy Consumption (EC)	First 200 kWh per month (RM 0.4350/kWh)	A = RM 0.4350/kWh x EC
	Next kWh (201 kWh onwards) (RM 0.509/kWh)	B = RM 0.509/kWh x (EC-200)
Imbalance Cost Pass Through (ICPT)	(RM 0.02/kWh)* (RM 0/kWh)**	C = RM 0.02 x EC Note: The coefficient value for ICPT is subjected to the enforcement date
Imbalance Cost Pass Through (ICPT) Rebate	(RM 0.02/kWh)***	D = RM 0.02 x EC Note: ICPT Rebate is subjected to the enforcement date
Renewable Energy Fund (KWTBB)	1.6%	E = 1.6% x (A + B)
Late Payment Penalty Charge	1%	F = (Outstanding Amount) x 1% x (No. of Days Outstanding / 30 days) Note: Imposed if payment of electricity bills is made later than 30 days after the bill date
Economic Stimulus Discount	2%	G = 2% x (A + B + C) Note: Available from 1/4/2020 until 30/9/2020
PEMULIH Discount	5%	H = 5% x (A + B + D) Note: Available from 1/7/2021 until 30/9/2021
Power Factor Surcharge	1.5% surcharge (for every 0.01 less than 0.85 power factor) 3% surcharge (for every 0.01 less than 0.75 power factor)	I = [(0.85 – 0.75) / 0.01 x 1.5% x EC (RM)] + [(0.75 – pf) / 0.01 x 3% x EC (RM)]
Total Electricity Cost		Total (2020) = A + B + C + E + F + G + I Total (2021) = A + B + D + E + F + H + I

* Enforcement date: 1/1/2020, ** Enforcement date: 1/7/2020, *** Enforcement date: 1/1/2021 – 31/12/2021

3.2 Observation and Field Data Collection

Observation and field data collection were conducted to understand closely the basic operations, equipment used, the area involved, and the maintenance process conducted. Environmental parameters such as air temperature, air velocity, and illuminance level were collected by using a handheld anemometer and a lux meter on the investigated area to ensure the compliance with MS1525 standard. The questionnaire was also distributed to the workers and administration staff of the investigated small industry to gather information on the behavior and knowledge of the staff towards energy management and savings. The questionnaire was divided into two sections. The first section related to awareness and motivation to reduce energy consumption and the second section was to determine energy usage behavior.

Energy Efficiency Index (EEI) is one of the indicators that can be used to monitor energy performance [21]. Generally, EEI can be viewed as the ratio of the energy input to the factor related to the energy using component. The saving targets are always based on the lowest EEI for the building [22]. Eq. (1) shows the calculation of EEI. In this study, the EEI was calculated based on the weight of keropok lekor produced as the factors related.

$$\text{EEI} = \frac{\text{Energy Input}}{\text{Factors Related to the Energy Using Component}} \quad (1)$$

3.3 End-Use Load Apportioning Identification

The next step was to identify the end-use load apportioning. Load apportioning is important to understand how much energy had been used on each piece of equipment such as pieces of machinery, fans, and lighting system. There are a few formulas that can be used to find out the calculation for energy consumption from Eq. (2) until Eq. (7).

To find the energy usage per day(kWh)

(Usage per day(hours) / 1000) x Watts of equipment x No. of equipments (2)

To find energy usage per month (kWh)

(Usage per day(hours) / 1000) x Watts of equipment x No. of equipments x No. of days used in a month (3)

To find energy usage per year (kWh)

Energy usage in a month x 12 (4)

To calculate energy consumption per day (RM)

Energy usage per day x 0.435 (5)

To calculate energy consumption per month (RM)

Energy consumption per day x No. of days used in a month (6)

To calculate energy consumption per year (RM)

Energy consumption per month x 12 (7)

3.4 Propose Suitable Energy Conservation Measures

The last step was to propose suitable and applicable ECMs for the investigated small industry. It is vital to investigate the situation and the restriction based on a financial perspective. Thus, a cost-benefit analysis was conducted to support the proposed ECMs to give a clear insight to the management for short-term and long-term energy-efficient management suitable to the company.

4. Results and Findings

This section discussed the results and the finding of the data collection and analysis. conducted.

4.1 Utility Bill Review

Figure 5 shows the electricity consumption of the investigated small industry for 2019. Total electricity consumption in 2019 was 18,612 kWh. The highest electricity consumption for 2019 was in June because it was the month of Eid. Starting from April 2019, the pattern of electricity consumption showed a steady increment as the industry was preparing for the celebration and more incoming bookings for vacuum-packed keropok lekor during the holy month of Ramadhan in May 2019. Operation hours during the fasting month were also extended from 8.30 pm to 12 midnight. Hence, this leads to higher energy consumption. The lowest energy consumption recorded for 2019 was during January with 1194 kWh. The total utility bill for 2019 was RM 9,295.93. June 2019 recorded the highest electricity cost with RM 922.27 and the lowest electricity cost in 2019 was during January, with RM 592.95.

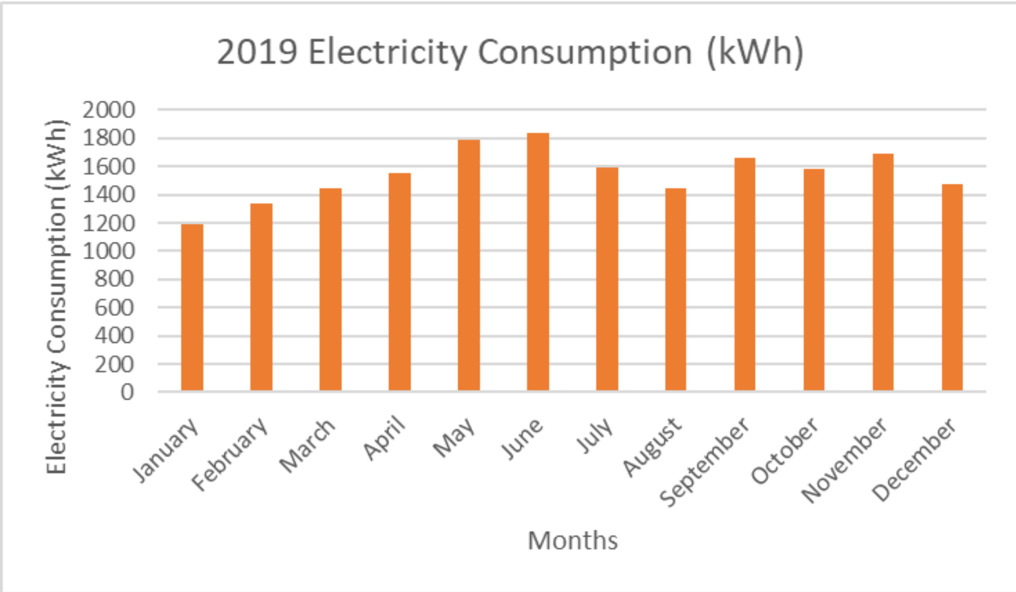

Fig. 5. Electricity consumption according to month in 2019

Table 3 shows the operation hours of the investigated small industry that was affected by the Covid-19 pandemic crisis. There was no operation during the Movement Control Order (MCO) in March and April 2020. Consequently, the operation was also reduced to 9 hours from May 2020 to June 2021.

Table 3
Operation hours based on the Malaysian Movement Control Order (MCO)

Phase	Date	Operation Hour
Movement Control Order (MCO)		
1	18th March 2020 – 31st March 2020	-
2	1st April 2020 – 14th April 2020	-
3	15th April 2020 – 28th April 2020	-
4	29th April 2020 – 3rd May 2020	-
Conditional Movement Control Order (CMCO)		
1	4th May 2020 – 12th May 2020	9
2	13th May 2020 – 9th June 2020	9
Recovery Movement Control Order (RMCO)		
1	10th June 2020 – 31st August 2020	9
2	1st September 2020 – 31st December 2020	9
3	1st January 2021 – 31st March 2021	9
MCO by state (11th January 2021 – 31st May 2021)		9
Total Lockdown (1st June 2021 – 28th June 2021)		9
National Recovery Plan		9
1	1st June 2021 – 28th June 2021 (depends on Covid cases in each state)	9

Figure 6 shows the electricity consumption by month for 2020 and 2021. The total electricity consumption was recorded at 14,811 kWh and 15,597 kWh for 2020 and 2021 respectively. The consumption was reduced by approximately 20% compared to consumption in 2019 due to MCO. As presented in Figure 6, electricity consumption in 2021 was higher from April to May because of the holy month of Ramadhan and preparation for the Eid celebration. Total electricity cost for 2020 and 2021 was RM 7,292.14 and 7,671.88 respectively, a reduction of more than 20% from 2019 which was RM 9,295.93. Table 4 shows the summary of the total electricity consumption and total electricity cost in 2019,2020 and 2021.

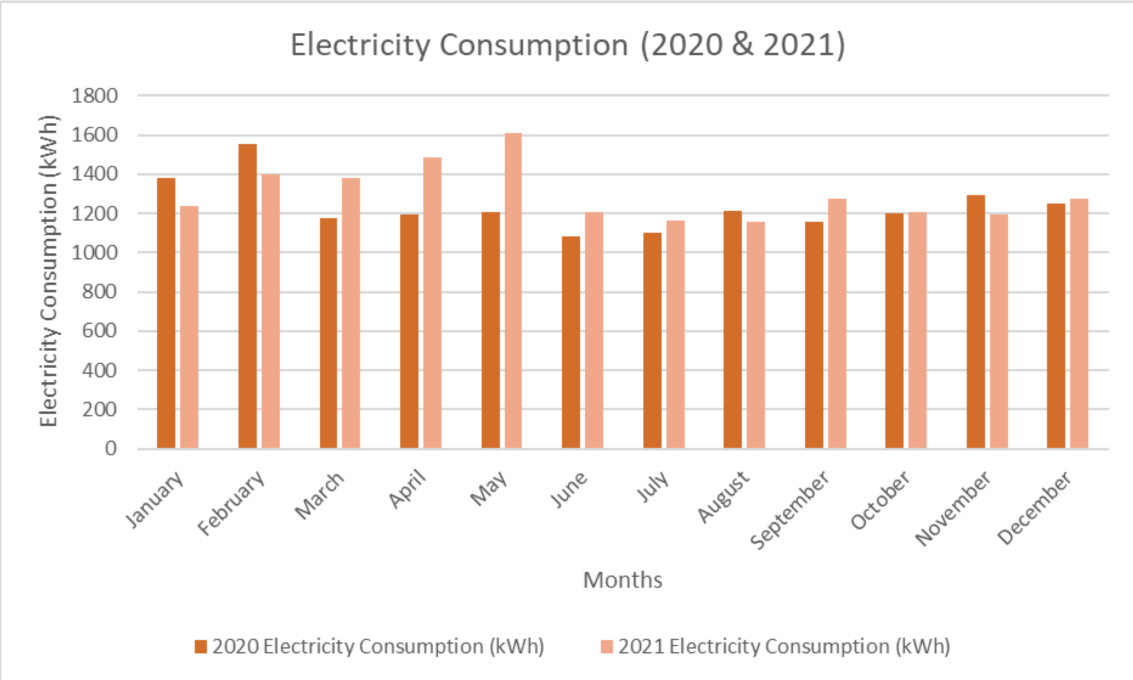

Fig. 6. Electricity consumption according to month in 2020 and 2021

Table 4
Summary of total electricity consumption and cost for 2019, 2020 and 2021

Year	Total Electricity Consumption (kWh)	Total Electricity Cost (RM)	Reduction Percentage (%)
2019	18,612	9,295.93	-
2020	14,811	7,292.14	20.4
2021	15,597	7,671.88	-

4.2 Energy Efficiency Index (EEI)

Factors that are closely related to energy usage in manufacturing space is the production of the keropok lekor itself. Figure 7 shows the total weight of keropok lekor produced by month in the year 2019. The average production was 3.3 tonnes per month.

Figure 8 shows the relationship between energy consumption per month and production of the keropok lekor during normal production in 2019. It showed that January has the highest EEI with 542 kWh/tonne. January 2019 was recorded as having the lowest energy consumption but only manages to produce just 2.2 tonnes of keropok lekor. The lowest EEI was recorded during June with 383 kWh/tonne. June 2019 was the month with the highest keropok produced in 2019 with 4.8 tonnes and consumed 1,841 kWh of electricity. The average EEI value for 2019 was 469 kWh/tonne. This result clearly showed that improvement could be done to increase the energy performance by lowering the EEI value. These results can be set as the baseline EEI to set the desired target EEI in the future.

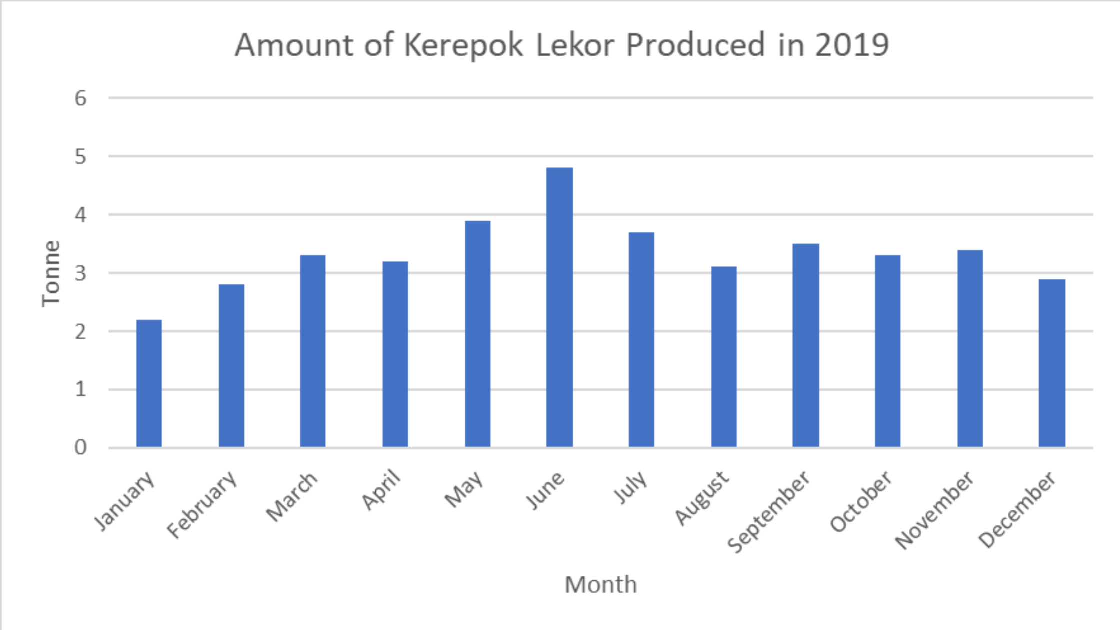

Fig. 7. Amount of keropok lekor produced by month in 2019

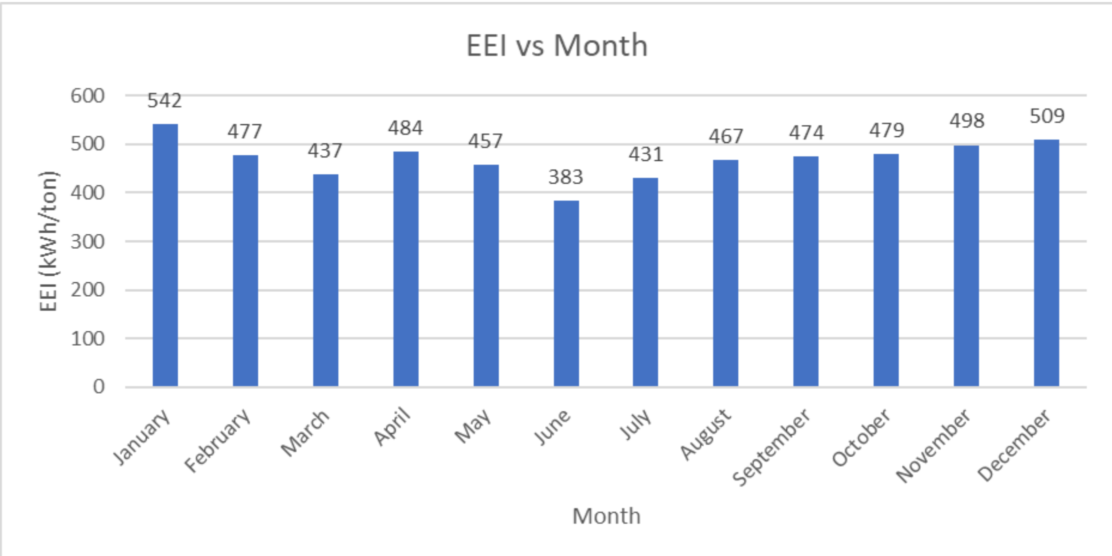

Fig. 8. EEI vs Month for 2019

4.3 Energy Load Apportioning

The electrical equipment was identified, and the rated power was recorded and multiplied by the number of operating hours. By utilizing Eq. (2) to Eq. (7), the total energy consumption for each piece of equipment was obtained as shown in Table 5. Figure 9 shows the end-use load apportioning with the highest 71% of the energy used for freezers and chillers, and 22% was used by the pieces of machinery.

Table 5
Description of lighting system

Lighting System	Quantity	kWh/month	RM/month	Switch (manual/auto)
8W Bulb	10	20.02	9.19	Manual
2ft T8 18W Fluorescent	8	37.44	16.29	Manual
Emergency lamp	2	14.40	12.53	Manual
T8 20W Fly Trap Fluorescent Lamp	2	11.48	5.97	Manual

Chiller and Freezer	Quantity	Rated Power (kW)	Function
Chiller Fridge (3 Doors)	1	1.02	Soft Drinks
Chiller Fridge (1 Door)	1	0.53	Frozen Products
Freezer	7	0.81	Raw Materials

Types of machinery	Quantity	Power (kW)	Function
Ice Crusher	1	0.3	Crush chunk of ice in the freezer into smaller pieces
Grinder	1	1.5	Grinds the raw material (fish) into smaller pieces
Mixer	1	1.5	Mixes the raw material with sago flour
Sealer	1	0.4	Seal the plastic package of frozen product to be
Vacuum Packer	1	1.6	Vacuum packed the sealed package

Fan	Place of Usage	Rated Power (W)	Quantity
Ceiling Fan	Manufacturing space	82	2
Wall Fan	Manufacturing Space	140	2
		120	2
Standing Fan	Boiling and Frying Space	160	1

Miscellaneous Equipment	Rated Power (W)	Quantity	Operation (hour/day)
Punch Card Machine	5	1	24
Air Blower	520	1	10
Cash Register	120	1	10

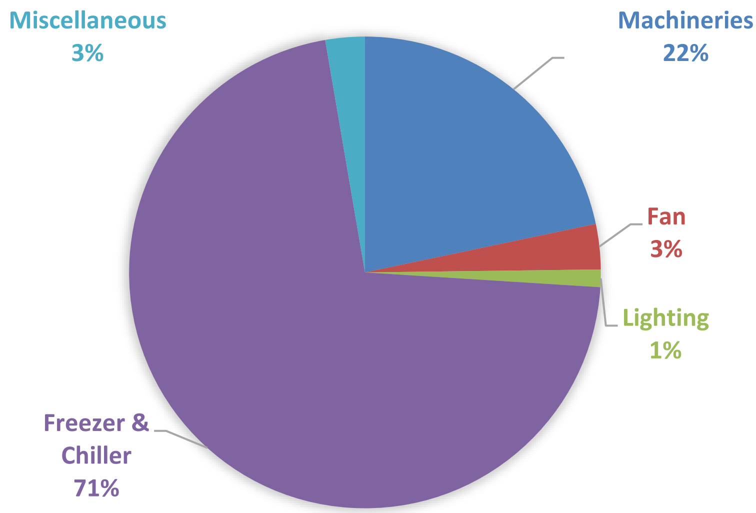

Fig. 9. Energy load apportioning

4.4 Lighting System Audit

Table 6 shows the average illuminance for each area in the building that is mainly divided into three parts which are the shop space, manufacturing space 1, and manufacturing space 2. The shop space average illuminance level was slightly over the recommended range while manufacturing space 2 was far below the recommended range suggested in MS1525 standards. It is suggested to increase the number of lightings in the manufacturing space 2 for a conducive working environment.

Table 6
Illuminance level

Location	Illuminance (Lux)		Remarks
	Measured	MS1525:2019	
Shop Space	751	200-750	Over
Manufacturing Space 1	427	300-500	Within
Manufacturing Space 2	88	300-500	Under

4.5 Indoor Air Quality Audit

Table 7 depicts the average measured air temperature in the investigated building. It can be observed that the average temperature in the building was slightly higher for the shop area and slightly lower for both the manufacturing spaces compared to the recommended outdoor design temperature stated in the MS1525 standard.

Table 7
Measured air temperature

Location	Measured Temperature (°C)		Remarks
	Measured	MS1525:2019	
Shop Space	34.4	33.3	+1.1°C
Manufacturing Space 1	31.8	33.3	-1.5°C
Manufacturing Space 2	33.2	33.3	-0.1°C

Table 8 shows the average air velocity inside the investigated building. All air velocity readings were within the recommended range except for manufacturing space 1 which has very low air movement.

Table 8
Measured air velocity

Location	Measured Air Velocity (m/s)		Remarks
	Measured	MS1525:2019	
Shop Space	0.58	0.15-0.50, max 0.70	Within
Manufacturing Space 1	<0.01	0.15-0.50, max 0.70	Under
Manufacturing Space 2	0.36	0.15-0.50, max 0.70	Within

The results of the indoor air quality audit suggest that the shop area had the highest average air temperature, however, the average air velocity was also the highest to give more thermal comfort condition to the occupant. Manufacturing space 1 had a very low average air velocity due to enclosed space and needs further investigation.

4.6 Questionnaire Responses

Based on the questionnaire distributed among the workers, 52% of the manufacturing and administrative staff shows a lack of awareness and have poor energy usage behavior which contributes to inefficient energy management.

4.7 Cost-Benefit Analysis

One of the suggested ECMs was to retrofit the lighting system with LED tubes. which could help to increase the illuminance level but with much lower energy consumption. It is also an ecologically sustainable option with high light quality and a natural lighting look. Through observation, a total of eight lamps were suggested to be retrofitted. Details of the proposed LED tube are shown in Table 9. Table 10 listed the comparison for both existing fluorescent lamps and proposed LED tubes in the investigated small industry.

Table 9
Proposed LED tube

Description	LED Tube 600mm 8W 740 T8
Rated Power (W)	8
Lamp Luminous Flux	800
Colour Temperature	4000
Price Per Unit (RM)	16.80

Table 10
Comparison between existing fluorescent and proposed LED tube

Description	Existing	Proposed
	Fluorescent T8 2ft	LED Tube 600mm
No. of Unit	10	8
Rated Power (W)	18	8
Lighting Load (kW)	0.180	0.064
Operating hour/day	10	10
Operating day/year	365	365
Total Energy Consumption (kWh/year)	657	233.6

The ROI calculation is based on retrofitting the Fluorescent T8 2ft to an LED tube as shown in Table 11. The result shows a significant decrease in usage of electrical energy and an increase in energy saving per year up to 64% with an estimated cost saving of RM181.14 per year. The investment for LED tube's payback period is 0.73 years and is suitable with the small company's resources. This ECM is considered a medium investment ECM.

Table 11
ROI for retrofitting fluorescent T8 to LED tube 600mm

Description	LED Tube 600mm
Estimated energy saving (kWh/year)	423.4
Energy saving (%)	64.44
Estimated cost saving (RM/year)	184.18
Price of light per unit (RM)	16.80
Estimated investment (RM)	134.40
Payback period (Year)	0.73

Solar panel installation cost-benefit analysis was conducted using the net energy metering (NEM) calculator. Return on investment (ROI) for installing solar panels by implementing the NEM incentive by the government is presented in Table 12. However, the minimum upfront cost was RM 55,800 with an estimated monthly saving of RM 774.66. Since the upfront cost for the solar panels is quite high, the payback period is estimated to be 6 years. This ECM is considered a high-cost investment ECM.

Table 12
ROI for installing solar panel

Description	Total
Average Current Monthly Bill (RM)	774.66
Monthly Bill after NEM (RM)	1
Monthly Saving (RM)	773.66
Proposed Installed Capacity (kWp)	15.5
Estimated Minimum Upfront Cost (RM)	55,800
Payback period (Year)	6.0

4.8 Identification of Applicable Energy Conservation Measures (ECMs)

After conducting preliminary energy usage analysis, observation and field data collection, end-use load apportioning, lighting, and indoor air quality audit, questionnaire response analysis, and cost-benefit analysis, a list of applicable ECMs was shortlisted as shown in Table 13.

Table 13
Applicable energy conservation measure solution

Applicability	Type of Investment	Proposed ECM	Remarks/ Implication
Yes	No cost/Low cost	Awareness Training Program Regarding Energy Efficiency	Can be done with a low budget which can be carried on from year to year
Yes	No cost/Low cost	Communal Work to Organize Items in Chiller and Freezer	Can be organized easily by having a strategic schedule
Yes	No cost/Low cost	Communal Work to Clean Electrical Equipment	Can be organized easily by having a strategic schedule
Yes	No cost/Low cost	Reduce the Number of Operating Freezers	Reservation and buying of raw materials can be revised to make sure an optimum number of freezers are used each time
Yes	Medium Cost	Retrofit T8 Fluorescent to LED Tube	Very Applicable because the investment made can be refunded in less than a year
No	High Cost	Purchase high energy efficient electrical appliances	Need to have enough savings and have strategic usage of equipment first before buying high-cost tools and pieces of machinery
No	High Cost	Installing Solar Panel	Too high cost for the size of current business and long time for a payback period to be over

5. Conclusions

An energy profiling study for a case study of keropok lekor small manufacturing industry had been carried out. The results showed that the energy consumption reduce by approximately 20.4% in 2020 and 2021 due to restricted movement control orders during the Covid-19 pandemic crisis. The average EEI based on the weight of keropok lekor produced during the normal operation in 2019 was

469 kWh/tonne with the lowest EEI being 383 kWh/tonne suggesting there was room for improvement in energy performance. Results obtained from lighting and indoor air quality audit showed that manufacturing space 2 needs to increase the illuminance level for a conducive workplace. The air velocity in manufacturing place 1 was very low due to the enclosed space and needs to be further investigated to enhance the thermal comfort condition. The load apportioning analysis showed that 71% of the energy was utilized by the freezers and chillers and another 22% was used by the pieces of machinery. Results of the questionnaire also showed that 52% of the staff had limited awareness and knowledge of energy saving. A low-cost investment in ECMs was proposed including conducting awareness training, reducing and organizing the chillers and freezers, and cleaning pieces of machinery and electrical equipment for efficient usage and increased manufacturing productivity. The cost-benefit analysis of the medium-cost investment of retrofitting LED tubes showed 64.4% energy saving yearly which is equal to RM 184.18 per year with a 0.72 payback period time. The high-cost investment ECM by using solar panels could save RM774.00 per year with a payback period of six years. Overall, the energy profiling study was successfully conducted and applicable ECMs with cost-benefit analysis were also had been proposed to the small industry for effective energy management.

Acknowledgement
This research was supported by the Ministry of Higher Education (MOHE) of Malaysia through Fundamental Research Grant Scheme (FRGS/1/2020/WAB02/UTHM/02/7). The authors acknowledged the Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia for its support. The author would also like to thank the administrative and workers of the investigated keropok lekor small industry for their help and commitment to conducting this energy profiling study.

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