Towards Sustainable Buildings Community College: An analysis of Energy Consumption at KKSS, Malaysia

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Abstract

The growing demand for energy and the push to enhance indoor environmental quality necessitate innovative strategies to promote energy efficiency and conservation in buildings. This research aimed to evaluate energy consumption in a community college building located in Kampung Sungai Sejuk, Sungai Siput, Perak, focusing primarily on an analysis of installed appliances. Detailed evaluations were made regarding appliance power ratings, their locations across different room types, and their usage durations. Based on the acquired data, the aggregate energy consumption of the building was estimated, encompassing aspects like illumination, office equipment, air conditioning, and other relevant variables. This analysis was conducted in accordance with the Efficient Management of Electrical Energy Regulations 2008 (EMEER 2008). Upon conclusion, the study successfully identified viable and economically efficient avenues for energy savings, shedding light on energy conservation opportunities (ECOs) within the building. In addition to these findings, the economic implications of the facility's energy usage were assessed. An evaluation of the Building Energy Intensity (BEI) is currently in progress to benchmark against the designated standards for governmental structures in Malaysia.

Keywords: Energy consumption, Energy Audit, Preliminary Energy Audit (PEA), Sustainable Buildings, Energy efficient

1.0 Introduction

Energy is pivotal to urbanization, development, and modernization. Rapid urbanization and population growth in developing countries have resulted in heightened energy intensity. In 2016, the residential and commercial sectors accounted for approximately 14% of a nation's total energy consumption [1–4]. Malaysia, in its commitment to sustainability, has pledged to reduce its carbon emission intensity of Gross Domestic Product (GDP) by 45% by 2030, using 2005 levels as a reference [5]. The 11th Malaysia Plan outlines ten strategic thrusts to meet its objectives. Notably, the pursuit of green growth to ensure sustainability and resilience is the sixth strategic thrust. Central to this initiative is the emphasis on sustainable production and consumption, which includes the use of demand side management strategies for energy optimization [6].

Energy audits are indispensable for conserving energy in buildings, as underscored by prior research discussed in this article. Singh et al. [7] demonstrated that improved efficiency significantly reduces energy wastage. Ali Alajmi's 2012 study revealed that energy audits equip building owners with the knowledge to evaluate the integration of emerging energy-saving technologies into existing structures [8]. Operational efficiency enhancements and alignment between expected and actual building performance can be realized through continuous commissioning and routine energy audits [9].

2.0 Methodology

A walk-through audit, also referred to as a Preliminary Energy Audit (PEA), is a systematic procedure used to identify potential energy savings through a visual inspection of the premises. This inspection covers various components, including the air conditioning system, lighting, metering, building automation, maintenance, and other elements influencing the building's energy consumption. The process flow of the PEA is depicted in

Figure 1.

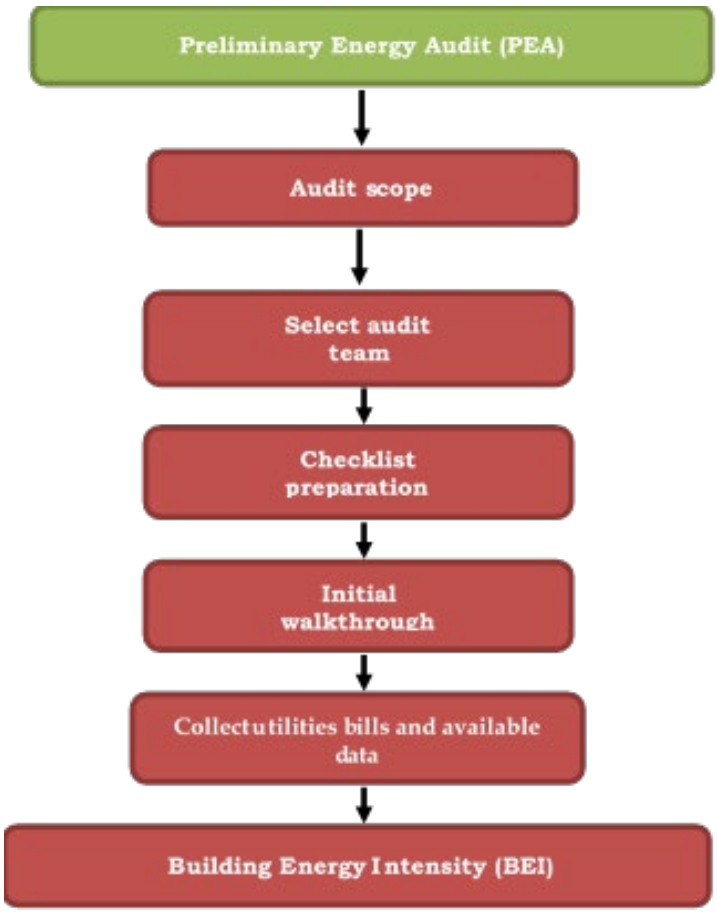

Figure 1: Energy audit flow chart of Preliminary Energy Audit (PEA)

The objective of this audit is to gain a comprehensive understanding of energy savings. Utilizing readily available resources like equipment rating records, technical catalogues, and operation and maintenance (O&M) manuals can significantly aid in the swift assessment of equipment or system efficiency. Quantifying the potential savings from the implementation of identified Energy Conservation Measures (ECMs) necessitates calculations, which are generally straightforward. This study employed a walk-through or preliminary energy audit, as depicted in

Figure 1, for the complete energy audit of Kolej Komuniti Sungai Siput. The PEA was conducted over two days, from 22nd to 23rd March 2022, and adhered strictly to the standards set by the Efficient Management of Electrical Energy Regulations 2008 (EMEER 2008) [10].

3.0 Result and Discussion

The data primarily presents details of energy consumption from four main applications. Figure 2 labels an "others" category at 10%, comprising electrical appliances such as closed-circuit television (CCTV), telephone, router, speakers, water-filtered drinking machines, and kitchen appliances.

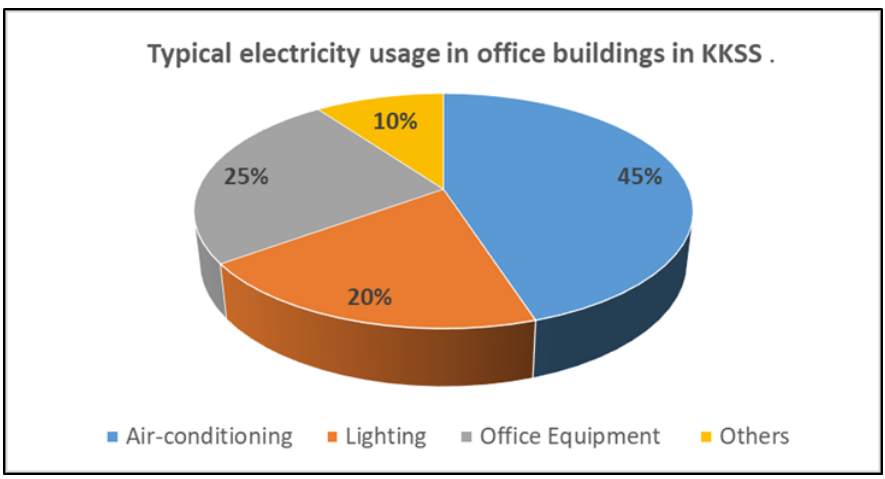

Figure 2: Typical electricity usage in office buildings in KKSS

From the analysis, air conditioning accounted for the highest proportion (45%) of the monthly electricity bill for the KKSS building, followed by lighting (20%) and office equipment (25%), which includes desktop computers, scanners, printers/photocopiers, and IT servers. Figure 2 illustrates that the annual energy consumption at the KKSS building was 392,080 kWh. Notably, there was a significant drop in energy consumption from 2020 to 2021, decreasing from 320,189 kWh to 254,277 kWh. This decrease is associated with the number of working days, the number of days in a month, and the number of class

days at KKSS, especially in the periods before and after the COVID-19 pandemic.

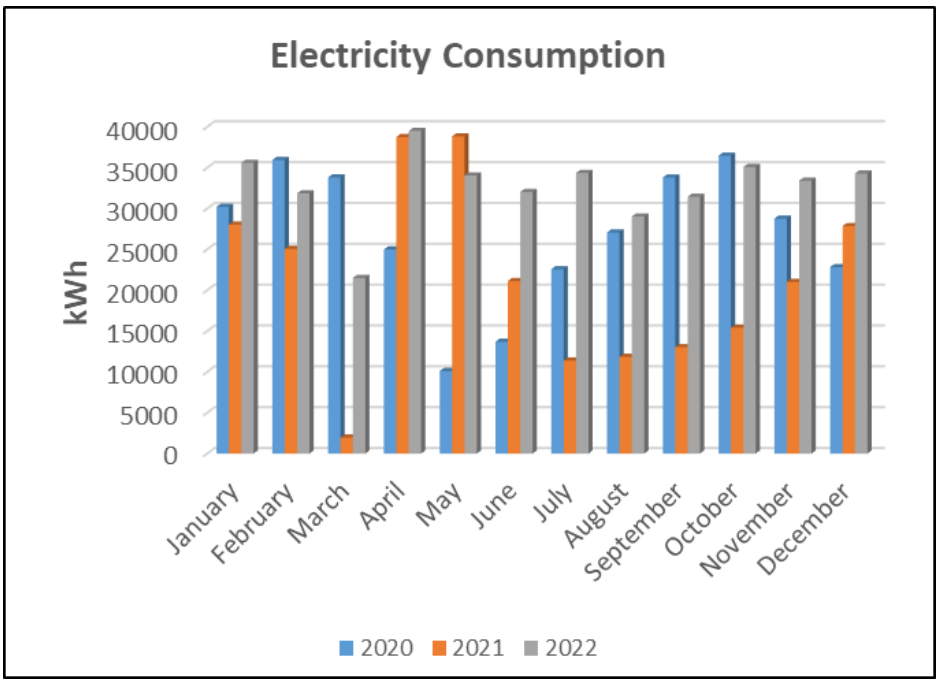

Figure 3: Electricity consumption at KKSS Office Building

Figure 3 illustrates the annual energy bill for the KKSS building from 2020 to 2022, during which COVID-19 was endemic. The years affected by endemic COVID-19 recorded higher electricity bills, amounting to RM 196,387.55 in 2020, RM 132,827.70 in 2021, and RM 149,542.50 in 2022, as depicted in Figure 4. Consequently, the KKSS Management should consider methods to reduce energy consumption by implementing cost-free measures, eliminating the need for financial outlay or dependence on funding from the ministry department. These cost-free measures require only time, focused attention, innovative thinking, self-discipline, and persistence. A benchmarking tool is utilized to monitor building energy performance, specifically to evaluate the energy intensity per unit area of the building [11].

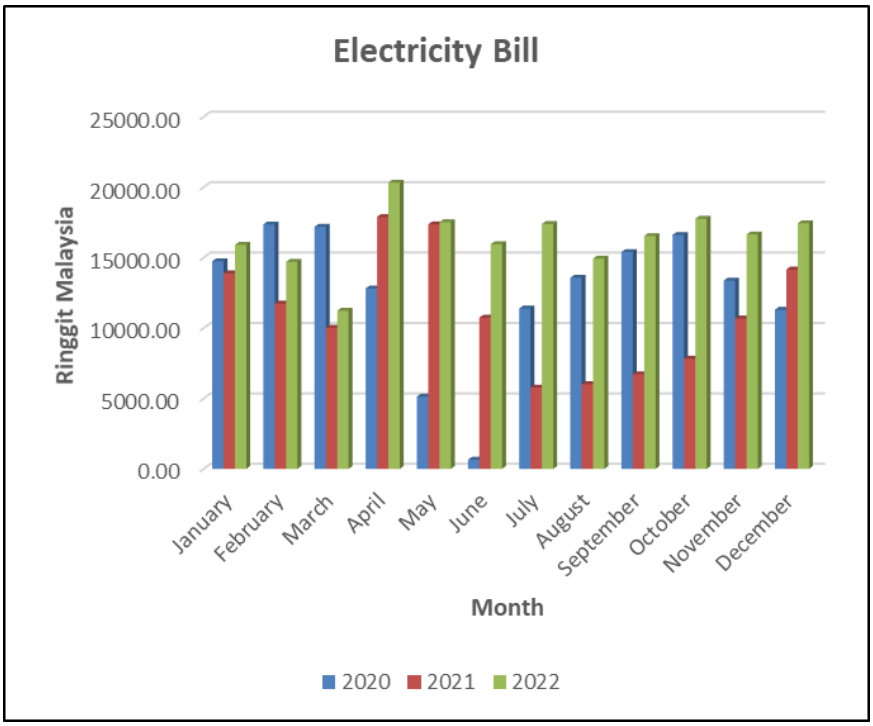

Figure 4: Monthly Electricity Bill at KKSS Office Building

The index is calculated by dividing the building's annual energy consumption (measured in kWh per year) by its net floor area (expressed in square meters, m^2). $\boldsymbol{BEI}\ (\boldsymbol{kWh/m^2/year}) = \frac{\mathbf{AEC(kWh)}}{\mathbf{NFA(m^2)}}$ (1)

*AEC = annual energy consumption (kWh)

*NFA = nett floor area (m^2)

Table 1: National building energy intensity (BEI) for government building

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

The Energy Commission of Malaysia introduced the Building Energy Intensity (BEI) labelling for government buildings in the fourth quarter of 2018. This program aims to attach BEI labels to 5,000 government buildings, drawing from energy intensity data of the previous year. Estimates suggest that an increase of one-star rating level above the initial level could lead to savings of 521 GWh or RM190 million [12]. Table 1 displays the range of the Building Energy Index (BEI) and the associated Star rankings for the National Building Energy Label certification, as determined by the Energy Commission of Malaysia. Moreover, Figure 5 offers a visual representation of the BEI label awarded to an institution that falls within a given BEI range.

Figure 5: Building energy label (BEI Label) by Energy Commission of Malaysia

Table 2: BEI for KKSS building for 2020 – 2022

Year	AEC (kWh/year)	BEI (kWh/m²/year)	Carbon Footprint (kg/CO²)
2020	320,189	27.04	320,188.15
2021	254,277	21.47	254,276.15
2022	392,080	33.11	392,079.15

The preliminary energy audit (PEA) analysis indicates that the KKSS building had an energy intensity of 33.11

kWh/m^2/year in 2022, compared to 27.04 kWh/m^2/year in 2020 and 21.47 kWh/m^2/year in 2021. This BEI value suggests that KKSS has the potential to qualify for the 5-Star BEI Label certification. Achieving this could accelerate efforts to enhance the energy efficiency of government buildings, leading by example for other institutions, such as polytechnics and community colleges. Table 2 indicates that KKSS produced carbon dioxide emissions totaling 392,079.15 kg/CO2 for 2022, in contrast to 320,188.15 kg/CO2 in 2020 and 254,276.15 kg/CO2 in 2021. The achievement in BEI also assists government agencies in identifying carbon dioxide emission levels contributing to the greenhouse effect. Hence, lower BEI values correlate directly with reduced greenhouse gas emissions (GHG) intensity.

4.0 Conclusion

Based on the detailed walkthrough of the preliminary energy audit (PEA) and the energy performance analysis conducted in the KKSS building, the overall Building Energy Intensity (BEI) is determined to be 33.11 kWh/m^2/year. This finding aids the Malaysian Government in its national commitment to reduce greenhouse gas emissions (GHG) intensity of the Gross Domestic Product (GDP) by 45% by 2030.

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Author Contributions

K.K Chow: Original idea of study and conceptualization, Methodology, writing original draft preparation; **W.L. Lew:** Data curation, Software, Validation, Supervision, Software,

Validation, Touch-up writing, reviewing and editing.

Conflicts of Interest

The manuscript has not been published elsewhere and is not under consideration by other journals. All authors have approved the review, agree with its submission, and declare no conflict of interest in the manuscript.

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