

# Energy Audit and Energy Consumption Analysis of the Campus Building Operation of the State Polytechnic of Samarinda

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## ABSTRACT

Energy audits are essential for identifying the consumption patterns and enhancing the energy efficiency in buildings. This study investigates the energy use in two conventionally constructed buildings at the State Polytechnic of Samarinda: The Office of the Electrical Engineering Department (OEED) and the Office of the Mechanical Engineering Department (OMED). The key variables analyzed include temperature, relative humidity, Overall Thermal Transfer Value (OTTV), Roof Thermal Transfer Value (RTTV), and Energy Consumption Intensity (ECI) for both air-conditioned and non-air-conditioned spaces. In 2023, the average temperature and Relative Humidity (RH) were 28.8°C and 70.3% in OEED, and 28.4°C and 70.1% in OMED, respectively. The OTTV values were 61.51 W/m<sup>2</sup> (OEED) and 63.60 W/m<sup>2</sup> (OMED). ECI rose from 5.98 to 6.23 kWh/m<sup>2</sup>/month in OEED and from 4.57 to 4.85 kWh/m<sup>2</sup>/month in OMED between 2022 and 2023, yet remained within efficient benchmarks. However, the thermal comfort levels still necessitate air conditioning. The findings underscore the importance of implementing further efficiency measures to reduce the energy waste and improve sustainability on campus.

*Keywords-green building; energy operational; energy efficiency*

## I. INTRODUCTION

Indonesia's national energy demand is projected to annually grow by 4.7% from 2011 to 2030, exceeding the previous average of 3% (Indonesia Energy Outlook, 2013) [1, 2]. The transportation, residential, industrial, and commercial sectors are the primary consumers of electricity, with educational buildings categorized under the commercial sector. Globally, buildings account for nearly 40% of the total annual energy consumption [3, 4]. Monitoring the energy use in buildings is critical for identifying inefficiencies and informing conservation strategies. It has been shown that implementing energy management systems improves the energy performance, reduces waste, and lowers the emissions—contributing to global sustainability goals, as promoted by the UNEP and

UNIDO [4, 5]. Seasonal occupancy patterns and thermal comfort requirements have a significant impact on the energy demand in educational facilities, underscoring the importance of optimizing the building design and operation to minimize the energy consumption. Energy audits are a proven method for evaluating the energy performance and identifying the opportunities for conservation [7]. A typical audit includes site surveys, energy data collection, and analysis to propose cost-effective improvements [2]. Previous research has demonstrated that audits can reduce the energy use in residential [8, 9], commercial, and institutional buildings [10, 11], while also supporting compliance with the efficiency standards and raising awareness of the energy-saving practices [13]. This study conducts a Level 1 (walk-through) energy audit of two campus buildings at the State Polytechnic of

Samarinda: OED and OMED. The objective is to evaluate the actual energy usage, identify the Energy Management Opportunities (EMOs), and propose conservation strategies that do not compromise the occupant comfort. The audit examines the indoor temperature, humidity, energy consumption patterns, and the performance of the building envelope. The findings aim to inform campus energy policies, guide resource planning, and promote energy-efficient practices across the university facilities.

## II. LITERATURE REVIEW

An energy audit of the Director's Building at PT Perkebunan Nusantara XIII (Persero) revealed that the electricity consumption was predominantly driven by air conditioning systems (57.36%), followed by office equipment (38.10%) and lighting (4.54%) [14]. The audit calculated both Gross and Net ECI, identifying significant opportunities for savings through the replacement of conventional air conditioning units with inverter models. Comparative studies consistently demonstrate that green-certified buildings outperform conventional ones in both the energy use and thermal behavior. Lower OTTV, RTTV, and ECI in green buildings reflect improved envelope performance and more stable indoor temperature and humidity conditions [15, 16]. Simulation studies in the hospitality sector have shown that passive envelope modifications—such as façade-mounted sunshading—can reduce the cooling loads by up to 16%, as measured by indicators, like Predicted Mean Vote (PMV), Predicted Percentage of Dissatisfaction (PPD), and effective temperature [17]. These outcomes reinforce the importance of integrated envelope design and climate-responsive strategies in energy-efficient architecture. Research in developing countries has categorized HVAC optimization strategies into tiers based on cost and complexity, ranging from low-cost equipment tuning and zonal control to mid-range passive solar methods and advanced innovative HVAC systems [18]. Substituting fluorescent lamps with LEDs further reduced the lighting energy use and internal heat gains, which lowered the cooling demand. These findings underscore the value of audits in diagnosing inefficiencies and guiding retrofits, as demonstrated in [19, 20]. Daylighting, though difficult to quantify due to architectural dependencies, also shows a strong potential. One methodology, guided by simulation tools and energy efficiency standards, achieved up to 34% lighting energy savings and measurable CO<sub>2</sub> reductions by optimizing daylight in core and perimeter zones [21]. To meet the performance targets, buildings must comply with HVAC, lighting, OTTV, and RTTV standards. Factors, such as the WWR, glazing type, insulation, material conductivity, orientation, and shading devices all significantly impact the thermal performance and energy use [22, 23].

Optimizing WWR and wall geometry, along with incorporating shading strategies, can reduce the heat gain and cooling loads. Overall, the literature supports a multi-faceted approach that combines active system upgrades, passive design, regulatory compliance, and continuous monitoring. However, research gaps remain, particularly in the post-occupancy evaluation and empirical validation of simulation models in tropical contexts. Future studies should prioritize

interdisciplinary, climate-specific frameworks to advance sustainable and efficient building practices.

## III. RESEARCH METHODOLOGY

National policy emphasizes the importance of conserving energy and water in public sector operations, highlighting efficient electricity use as a key priority in government-owned buildings [10]. This study aims to conduct an energy audit to examine the energy usage patterns and identify areas for potential conservation. ECI, both Gross and Net ECI, is calculated as part of the audit process. According to guidelines from the Ministry of National Education and ASEAN-USAID (1992), the building energy consumption is categorized into air-conditioned and non-air-conditioned spaces. The design and conservation standards for building envelopes follow the Indonesian National Standard (SNI) 6389-2011, while the energy auditing procedures are guided by SNI 6197-2011 to ensure energy efficiency without compromising the occupant comfort.

This research adopts a quantitative approach, using observation, measurement, and experimental techniques. A case study method is applied to two campus buildings located in Samarinda City, East Kalimantan Province. The key parameters observed include the energy consumption, efficiency, cooling load, occupancy rate, and thermal comfort. Data collection took place between June and December 2023. Historical electricity data from 2022 and 2023 were used to calculate the monthly ECI (kWh/m<sup>2</sup>), with real-time monitoring provided by an Electrical Monitoring Wireless Sensor Network (EM-WCN) connected to a web-based server.

The temperature and RH were measured using a thermohygrometer placed in multiple rooms at three intervals each day—morning (07:00–09:00), noon (11:00–13:00), and afternoon (15:00–17:00)—on selected dates in August, September, and October 2023. To calculate the OTTV, the analysis considered several parameters: solar radiation absorption, thermal transmittance of walls (W/m<sup>2</sup>°C), WWR, the equivalent temperature difference between the indoor and outdoor surfaces, solar radiation factor (W/m<sup>2</sup>), and the Shading Coefficient (SH) of windows or other openings. The RTTV was calculated to evaluate the heat gain through the roof structure. The RTTV calculations included variables, such as the transparent roof area (m<sup>2</sup>), the temperature differential between the interior and exterior environments (°C), the roof light area (m<sup>2</sup>), the transmittance of the roof material (W/m<sup>2</sup>°C), and the shading or lighting coefficient. These parameters were used to compute the building envelope's thermal performance and identify areas of excessive heat gain [23]. The ECI was also calculated separately for air-conditioned and non-air-conditioned spaces, based on the location and energy usage. These values, recorded via the EM-WCN system, were critical in evaluating the operational efficiency. To support the analysis, several standard equations were employed to compute OTTV, RTTV, and the total OTTV, based on established models that incorporate structural and environmental variables [15-17]. The collected data were compared with thermal comfort benchmarks to evaluate the building's performance. The OTTV and RTTV values were evaluated to measure the thermal efficiency of the envelope,

while ECI figures were benchmarked against national energy efficiency standards. As no prior energy audits had been conducted on the OEED and OMED buildings at Politeknik Negeri Samarinda, their energy performance was previously undocumented. This study provides essential baseline data. Through this methodology, the study aims to provide a comprehensive assessment of the energy consumption and propose practical strategies for enhancing the energy efficiency in campus buildings.

The partial OTTV equation is described by (1), RTTV by (2), and total OTTV by (3):

$$OTTV = \alpha \left( (U_w \times (1 - WWR)) \times T_{Dek} \right) + (SC \times WWR \times SF) + (U_f \times WWR \times \Delta T) \tag{1}$$

$$RTTV = \frac{[(Ar)(Ur)(\Delta T_{eq}) + (As)(Us)(\Delta T) + (As)(SC)(SF)]}{Ar + Ar} \tag{2}$$

$$OTTV_{total} = \frac{[(An \times OTTV_n) + (Ae \times OTTV_e) + (As \times OTTV_s) + (Aw \times OTTV_w) + (A_{roof} \times OTTV_{roof})]}{(An_{orth} + Ae_{east} + As_{south} + Aw_{west} + A_{roof})} \tag{3}$$

IV. RESULTS AND DISCUSSION

A. Measurements of Temperature and Relative Humidity

Direct measurements of the indoor temperature and RH were conducted in the OEED and OMED buildings using a

TABLE I. RESULT OF TEMPERATURE AND RH MEASUREMENT IN OEED AND OMED BUILDING

Time measurement			OEED		OMED	
			Temperature (°C)	RH (%)	Temperature (°C)	RH (%)
Day 1 :	Morning	07:00 to 09:00	28.3	69.7	27.4	70.2
26/8/23	Noon	11:00 to 13:00	29.9	71.4	30.6	69.6
	Afternoon	15:00 to 17:00	29.4	70.6	29.5	70.1
Day 2 :	Morning	07:00 to 09:00	27.6	69.3	27.5	69.9
24/9/23	Noon	11:00 to 13:00	29.1	70.6	30.2	70.2
	Afternoon	15:00 to 17:00	29.8	70.2	28.7	70.2
Day 3 :	Morning	07:00 to 09:00	27.7	69.9	27.1	69.8
21/10/23	Noon	11:00 to 13:00	28.3	71.4	28.9	70.2
	Afternoon	15:00 to 17:00	29.5	69.7	29.2	70.1
Average			28.8	70.3	28.4	70.1

TABLE II. WINDOWS TO WALL RATIO EXISTING IN OEED AND OMED BUILDINGS

Area	Orientation	OEED		OMED	
		WWR	WWR (%)	WWR	WWR (%)
1 <sup>st</sup> floor	North	0.54	54	0.071	7.1
	East	0.00	0	0.307	30.7
	South	0.58	58	0.122	12.2
	West	0.00	0	0.307	30.7
2 <sup>nd</sup> floor	North	0.56	56	0.071	7.10
	East	0.00	0	0.340	34.0
	South	0.69	69	0.071	7.10
	West	0.08	8	0.324	32.4

B. OTTV and RTTV Calculation

The thermal performance of the building envelope was assessed using OTTV and RTTV metrics, as specified in the SNI [24]. Calculations were conducted separately for each building orientation and floor in the OEED and OMED buildings to evaluate the heat gain through external walls and roofs. The walls of both buildings are constructed from 152 mm-thick reinforced concrete, with a density of 2,400 kg/m<sup>3</sup> and a thermal transmittance (U-value) of 3.58 W/m<sup>2</sup>.°C. The surface is finished with blue paint, contributing to a total solar absorptance (α) of 0.86. Window glazing consists of clear glass, with an SC of 0.86. Based on the calculated wall weight of 364.8 kg/m<sup>2</sup>, the construction is classified as heavy, and the equivalent temperature difference (ΔT<sub>eq</sub>) is set at 10 K, as per the standard. The WWR was calculated for each facade and floor, and is summarized in Table II.

thermohygrometer. Sampling took place in several key rooms on each floor during three weekends—August 26, September 24, and October 21, 2023. To ensure consistency, all measurements were taken with the air conditioning turned off for approximately ten min beforehand. Data were collected at three intervals per day: morning (07:00–09:00), noon (11:00–13:00), and afternoon (15:00–17:00), with a three-week interval between each round of measurements. It was noted that during the measurements, the sun was inclined toward the building's south side, which had an impact on the measurement outcomes in the rooms situated there. Table I summarizes the findings of the temperature and RH measurements made in the OEED and OMED buildings.

The measurements revealed that the average temperature in OMED was 28.4°C with a RH of 70.1%, while the OEED building recorded slightly higher values at 28.8°C and 70.3% RH. These levels exceed the Indonesian SNI thermal comfort guidelines, which define the optimal comfort conditions as 22.8–25.8 °C and 40%–60% RH. Additionally, afternoon sessions—particularly in south-facing rooms—consistently showed higher temperatures due to direct solar exposure, suggesting a thermal imbalance caused by building orientation and insufficient shading. These findings confirm that both buildings operate outside the proposed comfort conditions and therefore depend heavily on mechanical cooling to maintain the indoor thermal comfort.

To calculate the OTTV for each orientation of each wall side on floors 1 and 2 of the OEED and OMED buildings, (1)-(3) [15, 16] are used. For the RTTV analysis, the roof structures of both buildings are made of corrugated zinc sheets

with a thermal transmittance (U) of 3.18 W/m<sup>2</sup>.°C and a solar absorptance (α) of 0.26. The OEED roof covers 495 m<sup>2</sup>, while OMED's roof spans 550.44 m<sup>2</sup>. Since the OMED building does not feature skylights, the Solar Control (SC) and Shading Factor (SF) values were not applied. As the roof construction falls under the lightweight category (<50 kg/m<sup>2</sup>), ΔT<sub>eq</sub> was set to 20 K, following the standard provided in [24]. The results of the OTTV and RTTV calculations for OEED are summarized in Table III. The OTTV values on the north and south facade of OEED exceeded the SNI threshold of 45 W/m<sup>2</sup>, whereas the east and west facade remained compliant. The roof RTTV was calculated at 63.60 W/m<sup>2</sup>, also exceeding the allowable limit, indicating a significant heat transfer into the building. Based on Figure 1, the comparison showed that only the OTTV values on the north and south sides of the OEED building were below the SNI standard threshold. In contrast, the OTTV values on the east, west, and roof surfaces exceeded the SNI threshold of 45 W/m<sup>2</sup>. The RTTV for the OEED roof was calculated at 63.60 W/m<sup>2</sup>, confirming excessive heat transfer through the roof structure.

TABLE III. RECAPITULATION OF OTTV VALUE AND RTTV IN OEED BUILDING.

Area	OTTV value orientation (W/m <sup>2</sup> )				RTTVroof (W/m <sup>2</sup> )	OTTVtotal (W/m <sup>2</sup> )
	North	East	South	West		
1 <sup>st</sup> floor	77.18	23.81	79.08	23.81	63.60	61.51
2 <sup>nd</sup> floor	78.88	32.31	73.13	36.88		
Average	78.03	28.06	76.11	30.34		

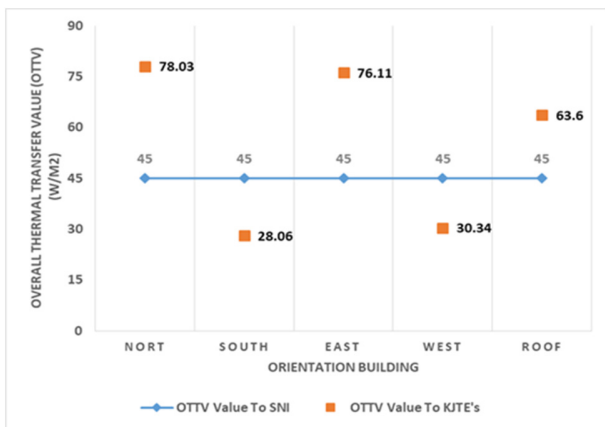


Fig. 1. Comparison of OTTV value with SNI in an OEED building.

The corresponding OTTV and RTTV results for the OMED building are depicted in Table IV. From the comparison graph evidenced in Figure 2, it can be observed that the OTTV values for the north and east facade of the OMED building remained within the acceptable threshold, whereas the south and west facade, as well as the roof, exceeded the 45 W/m<sup>2</sup> limit. Based on the OTTV calculation results for both buildings, it was found that the OMED building exhibited higher OTTV values on the south and west sides due to direct solar exposure. Conversely, the OEED building exhibited elevated OTTV values on the north and south facade, primarily due to the large glass window areas directly exposed to sunlight. This resulted in a greater level of heat radiation penetrating the indoor spaces of the OEED building.

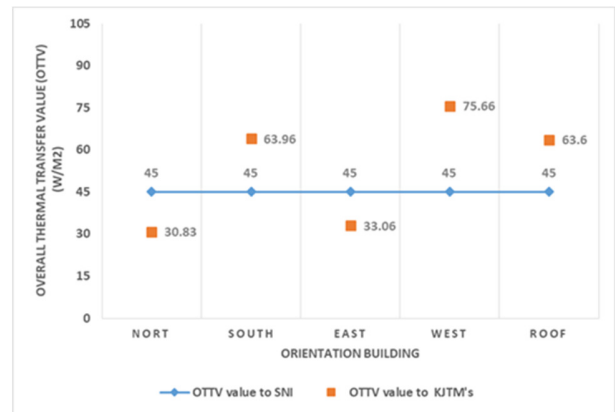


Fig. 2. Comparison of OTTV value with SNI in an OMED building.

TABLE IV. RECAPITULATION OF OTTV VALUE AND RTTV IN OMED BUILDING

Area	OTTV value orientation (W/m <sup>2</sup> )				RTTVroof (W/m <sup>2</sup> )	OTTVtotal (W/m <sup>2</sup> )
	North	East	South	West		
1 <sup>st</sup> floor	74.27	61.88	35.48	30.83	63.60	61.51
2 <sup>nd</sup> floor	77.04	66.05	30.65	30.83		
Average	75.60	63.96	33.06	30.83		

C. Calculation of ECI in AC and Non-AC Room in OEED and OMED Buildings

The ECI was analyzed for both the OEED and OMED buildings using monthly electricity consumption data from 2022 and 2023. The ECI values were calculated in kWh/m<sup>2</sup>/month, covering both air-conditioned and non-air-conditioned areas. In the OEED building, ECI ranged from 5.98 to 7.32 kWh/m<sup>2</sup>/month in 2022 and increased slightly to a range of 6.23-7.64 kWh/m<sup>2</sup>/month in 2023. For the OMED building, the values ranged from 4.16 to 4.91 kWh/m<sup>2</sup>/month in 2022 and from 4.24 to 5.29 kWh/m<sup>2</sup>/month in 2023. According to the national efficiency standards, these values are considered "Efficient." However, the year-over-year increase in both buildings suggests a gradual rise in the operational energy demand, which may impact the long-term energy sustainability and operating costs. There are two variables that can be calculated for a building's electrical ECI: Gross ECI, which includes the total area of both air-conditioned and non-air-conditioned rooms, and Net IKE, which is a detailed IKE with a clear separation between the total area of air-conditioned and non-air-conditioned rooms per unit. To gain a more detailed understanding of the energy use, ECI was calculated separately for the air-conditioned and non-air-conditioned areas. Tables VI-IX provide a breakdown of the consumption across lighting, HVAC systems, and other electrical equipment for each floor in both buildings.

Among all electrical equipment, the air conditioning systems consume the highest amount of energy, as they are essential for maintaining thermal comfort throughout buildings. As a result, the substantial electrical load from the HVAC systems significantly increases the operational costs of both facilities. According to the data presented in Tables VI-IX, 83.75% of the OEED building's floor area is air-conditioned, compared to 85.48% in the OMED building.

TABLE V. CATEGORY OF ENERGY CONSUMPTION OF THE OEED BUILDING 2022 AND 2023

Mth	2022		2023		Information
	ECI (kWh/m <sup>2</sup> /mth)	ECI (kWh/m <sup>2</sup> /y)	ECI (kWh <sup>2</sup> /mth)	ECI (kWh/m <sup>2</sup> /y)	
Jan	6.11	73.34	6.20	74.37	Efficient
Feb	6.06	72.72	6.44	77.24	Efficient
Mar	5.83	69.91	6.22	74.67	Efficient
Apr	6.09	73.03	5.93	71.16	Efficient
May	6.34	76.03	6.08	73.01	Efficient
Jun	6.31	75.68	6.37	76.42	Efficient
Jul	5.74	68.88	5.97	71.63	Efficient
Aug	5.88	70.53	6.55	78.57	Efficient
Sept	6.46	77.52	6.40	76.84	Efficient
Oct	5.63	67.54	5.50	65.98	Efficient
Nov	5.28	63.34	6.75	80.99	Efficient
Dec	6.01	72.16	6.31	75.76	Efficient

The analysis also included the distribution of energy consumption across major equipment categories, namely HVAC, lighting, and miscellaneous office devices. Figure 3 illustrates the proportion of electricity usage across categories in both buildings. HVAC systems accounted for the highest share, consuming approximately 70%-80% of the total

electrical energy. Specifically, the OEED building exhibited the highest HVAC-related energy use, whereas the OMED building showed higher consumption from lighting systems and other electrical equipment.

TABLE VI. CATEGORY OF ENERGY CONSUMPTION OF THE OMED BUILDING 2022 AND 2023

Mth	2022		2023		Information
	ECI (kWh/m <sup>2</sup> /mth)	ECI (kWh/m <sup>2</sup> /y)	ECI (kWh <sup>2</sup> /mth)	ECI (kWh/m <sup>2</sup> /y)	
Jan	4.29	51.54	4.49	53.94	Efficient
Feb	4.67	56.01	4.87	58.46	Efficient
Mar	4.54	54.49	4.62	55.38	Efficient
Apr	4.72	56.67	4.43	53.21	Efficient
May	4.91	58.97	4.81	57.69	Efficient
Jun	4.16	49.94	5.12	61.41	Efficient
Jul	4.55	54.55	5.22	62.63	Efficient
Aug	4.46	53.53	5.29	63.46	Efficient
Sept	4.86	58.33	5.04	60.51	Efficient
Oct	4.59	55.13	4.24	50.92	Efficient
Nov	4.25	51.03	5.28	63.41	Efficient
Dec	4.88	58.59	4.82	57.87	Efficient

TABLE VII. ECI IN AIR-CONDITIONED ROOMS OF THE OEED BUILDING

Area	Total area (m <sup>2</sup> )	Air-conditioned (m <sup>2</sup> )	Energy consumption (kW/day)			kW	Load (kW/day)	Load (kW/mth)	IKE (kwh/m <sup>2</sup> /mth)
			Lamp	HVAC	Other				
1st Floor	492	433	0.572	16.500	3.020	20.09	112.68	2475.70	5.72
2nd Floor	277	211	1.166	9.470	1.310	11.95	66.92	1472.24	6.97
	769	644	1.738	25.970	4.330	32.04	169.42	3947.94	6.34

TABLE VIII. ECI IN AIR-CONDITIONED ROOMS OF THE OMED BUILDING

Area	Total area (m <sup>2</sup> )	Air-conditioned (m <sup>2</sup> )	Energy consumption (kW/day)			kW	Load (kW/day)	Load (kWh/mth)	ECI (kWh/m <sup>2</sup> /mth)
			Lamp	HVAC	Other				
1 <sup>st</sup> Floor	468	400	571	20.170	6105	26846	150.33	3307.42	8.27
2 <sup>nd</sup> Floor	468	400	1.385	24.630	7690	33703	188.74	4152.21	10.38
	936	800	1.956	44.800	13.795	60548	339.07	7459.63	9.33

TABLE IX. ECI FOR NON-AIR-CONDITIONED ROOMS OF THE OEED BUILDING

Area	Total area (m <sup>2</sup> )	Non-air-conditioned (m <sup>2</sup> )	Energy consumption (kW/day)			kW	Load (kW/day)	Load (kWh/mth)	ECI (kWh/m <sup>2</sup> /mth)
			Lamp	HVAC	Other				
1 <sup>st</sup> Floor	492	59	0.105	0.350	0.455	2.55	56.06	0.950	492
2 <sup>nd</sup> Floor	277	66	0.288	0.250	0.538	3.01	66.22	1.002	277
	769	125	0.393	0.610	0.993	5.56	112.28	0.977	769

TABLE X. ECI FOR NON-AIR-CONDITIONED ROOMS OF THE OMED BUILDING

Area	Total area (m <sup>2</sup> )	Non-air-conditioned (m <sup>2</sup> )	Energy consumption (kW/day)			kW	Load (kW/day)	Load (kWh/mth)	ECI (kWh/m <sup>2</sup> /mth)
			Lamp	HVAC	Other				
1 <sup>st</sup> Floor	468	68	0.105	0.250	0.355	1.99	43.74	0.643	468
2 <sup>nd</sup> Floor	468	68	0.288	0.250	0.538	3.01	66.28	0.975	468
	936	136	0.393	0.500	0.893	5.00	110.02	0.809	936

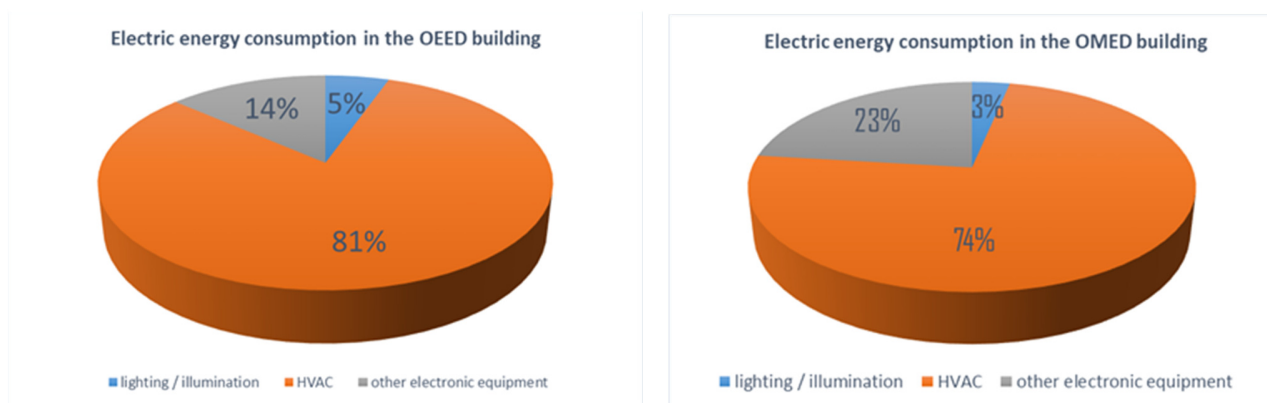


Fig. 3. Total electric energy consumption based on equipment usage in the OEED and OMED buildings.

#### D. Issues and Challenges of Energy Efficiency in Campus Buildings.

Achieving energy efficiency in campus buildings, such as OEED and OMED, is hindered by a combination of institutional, behavioral, and technical challenges. These issues must be addressed holistically to enable a sustainable energy management framework:

- **Inadequate Budget Allocation:** Institutional funding is primarily allocated to the procurement and upkeep of aging HVAC systems, many of which have been in operation for over three decades. Critically, there is no dedicated budget for energy efficiency initiatives or infrastructure upgrades, reflecting a lack of strategic prioritization by the campus leadership.
- **Limited Institutional Commitment:** Energy management programs are often absent from the organization's core agenda, hindering interdepartmental collaboration, access to expert consultation, and the execution of awareness campaigns. This lack of institutional support significantly reduces the effectiveness of any energy-saving strategies.
- **Restricted Community Involvement:** Efforts to implement energy efficiency measures typically involve only departments, excluding the broader academic community. Faculty members, technicians, administrative personnel, and students are often unaware of or not involved in such initiatives, which limits their overall impact.
- **Reactive Approach to Energy Management:** Energy managers are usually engaged only after the excessive energy consumption has been identified. Their involvement tends to be audit-focused rather than proactive, which limits opportunities for continuous improvement and real-time energy optimization.
- **Low Awareness and Cultural Engagement:** There is a widespread lack of awareness regarding energy efficiency practices among building occupants. While some initiatives have been introduced, they remain largely ineffective due to insufficient managerial guidance, lack of accountability structures, and minimal community engagement.
- **Outdated and Inefficient Equipment:** Much of the existing infrastructure consists of aging or malfunctioning

equipment that operates significantly below the current energy efficiency standards. The continued use of these systems leads to excessive daily consumption, undermining the sustainability efforts.

- **Manual Control of Systems:** The absence of integrated or automated control systems for lighting and HVAC significantly contributes to energy waste. Manual operation, particularly in unoccupied rooms, leads to prolonged and unnecessary energy consumption.
- **Inefficient Lighting Practices:** The current lighting systems rely on outdated technologies that consume more power than necessary. To address this, the facility department should prioritize the transitioning to LED lighting, increase the number of light points in workspaces, implement zone-based switching, and promote an energy-conscious behavior, such as turning off the lights when not in use.

These challenges underscore the need for a coordinated and strategic approach—one that includes budget restructuring, technological modernization, proactive management, and active involvement from the entire academic community.

#### V. CONCLUSION

The evaluation of the OEED and the OMED buildings at the State Polytechnic of Samarinda identified significant inefficiencies in thermal comfort and envelope performance. Despite ECI values falling within the efficient range, average indoor temperatures exceeding 28 °C and RH levels above 60% highlight a continued dependence on mechanical cooling systems.

OTTV values in both buildings exceeded the SNI threshold of 45 W/m<sup>2</sup>, reaching 61.51 W/m<sup>2</sup> OEED and 63.60 W/m<sup>2</sup> OMED. These high values primarily result from poor window orientation and solar exposure, which lead to elevated cooling loads. While typical of conventionally constructed buildings, these findings underscore the urgent need for passive envelope upgrades, including external shading, improved glazing, and orientation-aware design.

Between 2022 and 2023, the average monthly ECI rose from 5.98 to 6.23 kWh/m<sup>2</sup> in the OEED and from 4.57 to 4.85 kWh/m<sup>2</sup> in the OMED. Although these remain within the efficiency benchmarks, the upward trend suggests a growing

operational energy demand, which could impact the long-term sustainability and occupant well-being.

These results underscore the importance of regular energy audits and performance monitoring as tools for reducing energy waste, optimizing indoor comfort, and guiding retrofit priorities. They also support the development of a comprehensive campus-wide energy management strategy aligned with the national standards and sustainability goals. The immediate implementation of envelope and lighting improvements, along with investment in long-term monitoring, can help transition the educational facilities toward higher energy efficiency and climate resilience.

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