Performa: Media Ilmiah Teknik Industri
ISSN 1412-8624 (print) | ISSN 2620-6412 (online)
Vol. 24, No. 1, 2025, Page. 1-10
doi.org/10.20961/performa.24.1.72432

Lighting and Air Conditioning Evaluation using Lumen and CLTD Methods: A Case Study in the Library of Politeknik ATMI Surakarta

Hoedi Prasetyo*[1], Nicholas Lucky Baskara[2], Bayu Saputro[3], and Matius Damar Adi Pradhana[4]

Mechatronics Study Program, Politeknik ATMI Surakarta, Jl. Mojo No.1, Karangasem, Laweyan, Surakarta, Central Java 57145, Indonesia

Email: hoedi.prasetyo@atmi.ac.id[1], nicholas.20202037@student.atmi.ac.id[2], bayu.20202011@student.atmi.ac.id[3], matius.20202034@student.atmi.ac.id[4]

Abstract

Comfort is a crucial factor in supporting the intended use of a space, including library spaces. Some previous studies have successfully examined the comfort of library spaces. However, there is still a lack of research that simultaneously examines the aspects of visual comfort, thermal comfort, and energy conservation. This study aims to evaluate the comfort of library space, including lighting, air conditioning, and energy conservation aspects, with a case study conducted in the library of Politeknik ATMI Surakarta. The research stages include data collection and calculations, followed by result analysis. Lighting calculations use the Lumen method, while cooling load calculations utilize the Cooling Load Temperature Difference method. Result analysis is carried out through a comparison between observation results and calculations, referring to several applicable standards. The research findings indicate that the lighting level in the library space needs improvement through the addition of lights and the even distribution of lighting installations. Another alternative solution is the replacement of lights with LED types that are more energy-efficient. The installed air conditioning unit in the room is in line with the cooling load requirements. However, it is recommended to replace the Window-type air conditioning unit with a Split Wall type and to exchange their locations.

***Keywords**: visual comfort; thermal comfort; energy conservation*

1. Introduction

Illumination is a crucial factor in creating visual comfort within a space. Adequate lighting generates a bright environment, enabling occupants to see clearly and providing a psychologically comfortable effect (Kurniawan et al., 2022). Concerning health aspects, proper illumination can reduce eye strain and help prevent eye fatigue, especially when the space is used for activities that require clear and detailed vision, such as reading or working with a computer. Conversely, poor lighting can result in a dim environment, tired eyes, and difficulties for occupants, particularly in activities that demand concentration and precision (Extrada et al., 2021). Lighting also has implications for workplace safety. Poor lighting quality can lead to drowsiness, neck pain (Rahmayanti & Artha, 2016), and a decline in employee performance (Biantoro, 2017).

In addition to lighting, thermal comfort is also a crucial consideration in designing a space. Thermal comfort refers to the indoor air conditions that provide comfort for occupants, including temperature, humidity, cleanliness, and air circulation (ASHRAE, 2013). Poor thermal comfort can lead occupants to feel overheated, sweaty, shivery, and may trigger dehydration and respiratory issues, potentially disrupting health and work productivity (Fadhila & Santiasih, 2021). Therefore, it is essential to pay attention to thermal comfort aspects when designing a space to create comfortable conditions for occupants. The geographical conditions of Indonesia, which has a climate beyond the thermal comfort zone, pose a unique challenge in designing spaces (Talarosha, 2005). Nevertheless, achieving thermal comfort can be realized through natural room design or by using room conditioning units such as AC (Air Conditioners) (Risnandar, 2019).

The comfort of a space significantly influences the success of its intended purpose, and this holds true for library spaces. Libraries play a crucial role in higher education institutions, supporting learning, research, and providing quality access to information for the entire academic community. Activities within library spaces involve substantial mental work, such as reading and thinking, demanding a high level of concentration, thereby necessitating support for room comfort.

Several studies have been conducted to assess the visual comfort of library spaces. A study was conducted on a lighting energy audit on the building of the Universitas Sebelas Maret library, using the method of measuring lighting levels and analyzing the Energy Consumption Intensity (Suhardi, 2015). Similar research with the same method was also carried out by (Kurniasih & Saputra, 2019) at the Universitas Budi Luhur library in Jakarta, measuring natural lighting levels in the reading areas and comparing them with (Badan Standardisasi

[1]* Hoedi Prasetyo

Received 20th March 2023; Received in revised form 11th December 2024; Accepted 12th Desember 2024

Nasional, 2011). Measurement of lighting levels was also employed by (Andarini & Listianti, 2017) in library within the Universitas Sriwijaya environment. This research was accompanied by surveys to gather perceptions about the lighting quality from room users. Study by (Rezka Adi, 2019) optimized natural lighting in the library space of the Universitas Islam Negeri Walisongo Semarang using modeling and simulation software, Dialux Evo.

Several other studies have focused on thermal comfort investigations. Study by (Munawaroh & Elbes, 2019) employed a direct measurement method on the research object, encompassing temperature, humidity, and air velocity. The research also conducted a survey to assess users' perceptions of thermal comfort in the IBI Darmajaya Lampung library building. Similar research with a comparable method was undertaken by (Kusumawati & Nugrahaini, 2021) considering the additional aspect of room coloring that has psychological impacts on visitors.

While previous studies have successfully examined the comfort of library spaces, there are still aspects that can be improved. The first aspect is the absence of simultaneous investigations into both visual and thermal comfort. Room comfort is achieved when visual and thermal comfort are considered simultaneously (Prasetyo et al., 2020). The second aspect is that not all studies take energy conservation into account. When conducting a study on room comfort, it is essential to consider energy conservation aspects. According to the regulation (Peraturan Pemerintah Republik Indonesia Nomor 33 Tahun 2023 Tentang Konservasi Energi, 2023), energy conservation is the efficient and rational use of energy without reducing the necessary energy usage to support development. This means that all efforts to utilize energy to achieve room comfort must consider efficient and rational principles to maintain the sustainability of energy resources. For example, air conditioning units are often used to achieve thermal comfort in a room. A survey stated that electricity consumption in commercial buildings is mostly (>60%) used for room cooling (Balai Besar Teknologi Konversi Energi-BPPT, 2020). On the other hand, air conditioning units require relatively large electrical power, so their use needs to be designed accurately to prevent electricity wastage ((Tri Wahyu, 2019), (Renaldi et al., 2019)).

This study aims to evaluate the comfort of the library space at Politeknik ATMI Surakarta. The selection of the case study object was motivated by complaints from library visitors regarding the quality of lighting and air conditioning in the facility. The library management unit suspects these issues to be contributing factors to the declining trend in library visitation. In response to this condition, the library management unit endeavors to enhance the number of library visits. One of the strategies that can be implemented is enhancing visitor comfort while maintaining energy use efficiency. The evaluation conducted in this study focuses on aspects of lighting and air conditioning, while simultaneously considering energy conservation in accordance with applicable standards.

2. Research Methods

The general stages of the research can be seen in Figure 1. The first stage involves data collection, including room geometry data, usage schedules, visitor numbers, building construction details, identification of electrical equipment, lighting level measurements, and other supporting data.

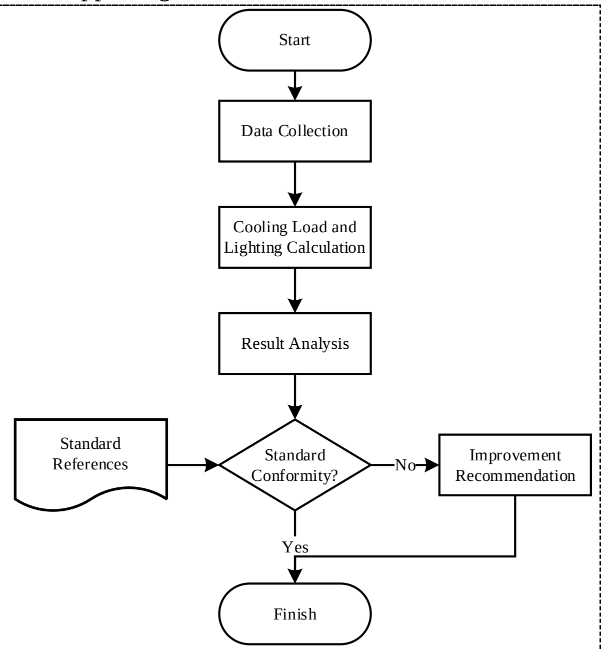

Figure 1. Method for Lighting and Air Conditioning Evaluation

Data collection is conducted through observation, interviews, and measurements. The next stage involves the calculation of lighting and cooling loads. Lighting calculations aim to determine the quantity and type of lamps needed, while cooling load calculations are performed to determine the required capacity of the air conditioning unit. Lighting calculations utilize the Lumen method (Badan Standardisasi Nasional, 2011) as shown in the following equation:

$$E = \frac{F . N . Kp . Kd}{A} \quad (1)$$

The variable F represents the luminous flux of the used light source (in lumens). Luminous flux is the amount of light energy emitted by a light source, such as a lamp, in all directions per second. Notation E is the standard illuminance level (lux). Illuminance, or sometimes referred to as illuminance, is the amount of light in lumens that strikes a surface area perpendicularly. Variable A is the area of the illuminated surface (m^2). Variable Kp is the utilization coefficient influenced by geometric size, reflectance level, and lamp housing type. Variable Kd is the depreciation coefficient influenced by room contamination level and the expected lamp lifespan. Meanwhile, *N* is the number of lamps required to achieve the specified illuminance level.

The distribution of light emitted by lamps onto the illuminated surface needs to be designated to ensure uniform coverage across the entire area. Adjusting the light distribution can be achieved by regulating the spacing between lamps. According to (Department of The Environment and Energy-Australia, 2019), the spacing between lamps is determined by the Spacing to Mounting Height Ratio (SHR) value, which can be calculated using equation (2). Variable *S* represents the spacing between lamps, while *H* is the height of the lamps from the horizontal lighting plane (m).

$$SHR = \frac{S}{H} \quad (2)$$

The cooling load calculation is performed using the CLTD (Cooling Load Temperature Difference) method recommended by ASHRAE (Bhatia, 2013). The CLTD method calculates the cooling load in units of BTU/hour based on two main components: the exterior cooling load (*Qext*) and the interior cooling load (*Qint*), as indicated by equation (3).

$$Cooling\ Load = Q_{ext} + Q_{int} \quad (3)$$

The exterior cooling load is the sum of values resulting from heat conduction through exterior walls (Q_{wall_ext}), windows (Q_{window}), air infiltration ($Q_{infiltration}$), and direct solar radiation passing through the glass (Q_{rad}), as indicated by the following equation:

$$Q_{ext} = Q_{wall\_ext} + Q_{window} + Q_{infiltration} + Q_{rad} \quad (4)$$

The value of Q_{wall_ext} is obtained from equation (5), where U_{wall_ext} is the heat transfer coefficient of the wall directly in contact with the outdoor air (BTU/hour ft² °F), A_{wall} is the wall area (ft²), and *CLTDc* is the corrected cooling load temperature difference (°F).

$$Q_{wall\_ext} = U_{wall\_ext} \times A_{wall} \times CLTD_C \quad (5)$$

The value of Q_{window} is obtained from equation (6), where U_{window} is the heat transfer coefficient of the window (BTU/hour ft² °F), A_{window} is the window area (ft²), and *CLTD* is the cooling load temperature difference value (°F).

$$Q_{window} = U_{window} \times A_{window} \times CLTD \quad (6)$$

The value of $Q_{infiltration}$ is obtained from equation (7), where *CFM* is the air infiltration rate, *ΔT* is the difference between the outside and inside temperatures (°F). The value of Q_{rad} does not need to be calculated since the room does not receive direct sunlight exposure.

$$Q_{infiltration} = 1.1 \times CFM \times \Delta T \quad (7)$$

The interior cooling load consists of heat conduction through interior walls (Q_{wall_int}), interior ceilings (Q_{roof_int}), floor (Q_{floor}), heat generated by human occupants (Q_{human}), lamps (Q_{lamp}), and electrical appliances (Q_{app}), as indicated by the following equation:

$$Q_{int} = Q_{wall\_int} + Q_{roof\_int} + Q_{floor} + Q_{human} + Q_{lamp} + Q_{app} \quad (8)$$

The value of Q_{wall_int} is obtained from equation (9), where U_{wall_int} _int is the heat transfer coefficient of the interior wall (BTU/hour ft² °F), A_{wall} is the wall area (ft²), and *ΔT* is the temperature difference between rooms (°F).

$$Q_{wall\_int} = U_{wall\_int} \times A_{wall} \times \Delta T \quad (9)$$

The value of Q_{ceil_int} can be calculated using equation (10), where U_{ceil_int} is the heat transfer coefficient of the interior ceiling (BTU/hour ft² °F), A_{ceil} is the ceiling area (ft²), and *ΔT* is the temperature difference between the upper and lower rooms (°F).

$$Q_{ceil\_int} = U_{ceil\_int} \times A_{ceil} \times \Delta T \quad (10)$$

The value of Q_{floor} can be calculated using equation (11), where U_{floor} is the heat transfer coefficient of the floor (BTU/hour ft² °F), A_{floor} is the floor area (ft²), and *ΔT* is the temperature difference between the floor and the room (°F).

$$Q_{floor} = U_{floor} \times A_{floor} \times \Delta T \quad (11)$$

The value of Q_{human} is obtained from equation (12), where *N* is the average number of occupants in the room, *Qs* is the sensible heat coefficient, and *Ql* is the latent heat coefficient.

$$Q_{human} = N \times (Qs + Ql) \quad (12)$$

The value of Q_{lamp} is obtained from equation (13), where P_{lamp} is the total power of the lamps, and *Fb* is the lighting control circuit factor.

$$Q_{lamp} = 3.41 \times P_{lamp} \times Fb \quad (13)$$

The value of Q_{app} is obtained from equation (14), where P_{app} is the total power of electrical appliances, and *Fp* is the usage factor.

$$Q_{app} = 3.41 \times P_{app} \times Fp \quad (14)$$

The next stage of the research involves analysing the results by comparing the calculation results with the actual conditions in the room and several applicable standards. The reference standard document used for lighting evaluation is SNI 6197-2020. This standard is an update of the previous one, SNI 6197-2011 (Setyaningsih et al., 2021). Some updates include the standard for lighting levels and power density for lighting. In the new standard, the standard lighting level for library spaces has changed from 300 lux to 350 lux, while the power density standard has decreased from 11 watts/m² to 10.33 watts/m².

Air conditioning evaluation is conducted using the reference standards SNI 03-6390:2020 (Konservasi Energi Sistem Tata Udara Bangunan Gedung, 2020) and Indonesian Regulation of Ministry of Energy and

Mineral Resources No. 14 of 2021 (Penerapan Standar Kinerja Energi Minimum Untuk Peralatan Pemanfaat Energi, 2021). If any discrepancies are found in the analysis results, recommendations for future improvements will be formulated.

3. Results and Discussion

This section presents the results of the conducted research. The initial stage of the study involved the collection of primary data through three methods: interviews, observation, and measurement. The interview method was conducted with library management staff to gain insights into the operational aspects of the library space and to obtain data that could not be measured directly, such as the type of building construction. The observation method was employed to identify the specifications of lighting fixtures, air conditioning units, other electronic equipment, and the building's construction features that could be readily determined through direct observation.

Meanwhile, the measurement method was used to assess room dimensions, lighting levels, as well as room temperature and humidity. Room dimensions were measured using a tape measure, lighting levels were measured using the Smart Sensor AS823 lux meter, and temperature and humidity were measured using the Smart Sensor AS847. Measurements were conducted once in the afternoon, between 2:00 PM and 3:00 PM. This time frame was chosen because the number of visitors is relatively higher during this period compared to other times, and the cooling load in the late afternoon is relatively high, making it an optimal time to evaluate air conditioning performance.

Based on the data collected, it is revealed that the library space at Politeknik ATMI Surakarta operates from 07:30 AM to 16:30 PM (Western Indonesian Time) with an average number of visitors around 6 individuals. The room has a maximum capacity of 18 people and dimensions of 13.6 meters in length, 7.96 meters in width, and 4 meters in height. The space is surrounded by four walls: the north, south, east, and west walls.

All walls are constructed using bricks and cement plaster with a thickness of approximately 10 cm (4 inches). The north and south walls serve as exterior walls, while the east and west walls are interior walls adjacent to other rooms. The ceiling is made of cast concrete with a metal sheet as the ceiling cover. The floor is made of cast cement and ceramic tiles. Detailed room shapes and layouts can be seen in Figure 2.

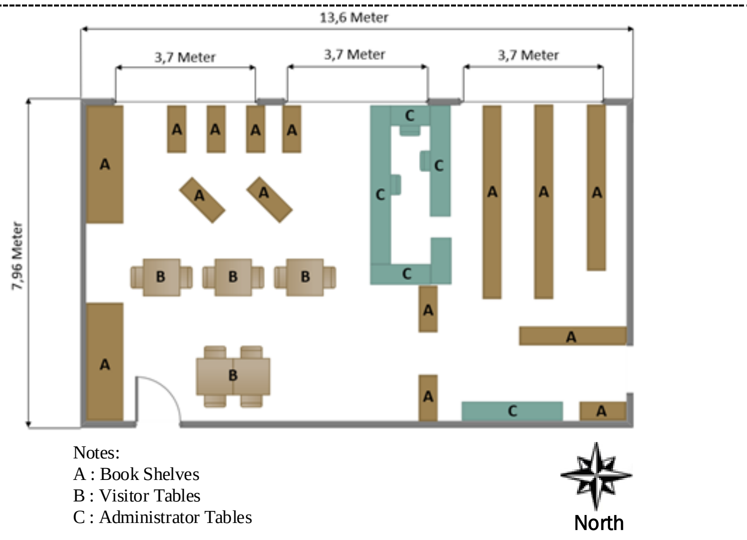

Figure 2. The Library Layout

The south and north walls are equipped with single clear glass windows with wooden frames that can be opened and closed. These walls are not directly exposed to sunlight as they are shielded by corridor constructions and canopies. The interior and exterior conditions of the room are illustrated in Figures 3 and 4.

Inside the library space, several gas discharge lamps are installed, including 13 Argon lamps with a power of 40 watts each and 2 Neon lamps with a power of 36 watts each. Argon lamps have a luminous flux of 2500 lumens, while Neon lamps have 2850 lumens. Additionally, there are 2 air conditioning units, Split Wall and Window types, and various other electrical equipment. The Split Wall air conditioning unit is installed on the west side of the south wall, while the Window type is installed on the east side of the south wall. The installation conditions of the lamps and air conditioning units can be observed in Figure 5.

3.1. Lightings Evaluation

Figure 6 depicts the layout of the lamp installations and the results of lighting level measurements at several points in the room. From the figure, it is evident that the layout of the lamp installations appears inconsistent and uneven.

Figure 3. Interior Views

(a) (b)

Figure 4. Exterior Views: (a) North Wall, (b) South Wall

(a)

(b) (c)

Figure 5. Lightings and Air Conditioner in The Room: (a) Gas Discharge Lamps, (b) The Split Wall AC, (c) The Window AC

Table 1 illustrates the comparison results between the standard lighting conditions and the actual conditions. Based on the collected lighting data, the aspects of color temperature and color rendering from the installed lamps are in accordance with the standards. Similarly, the power density, the total electrical power used for the lamps, is still below the maximum limit. However, the aspect of lighting levels still does not meet the standards. According to the measurement results, it is found that the average lighting level in the room is 140 lux. According to SNI 6197-2020, the standard lighting level for a library is 350 lux. This condition indicates that the lighting level in the library room requires improvement. Lighting improvement can be achieved by adding more lamps.

Table 1. Standard vs Actual Lighting Condition

Features	Standard	Actual	Conformity
Illuminance (lux)	350	140	No
Color Temperature (ºK)	> 3300	4100	Yes
Color Rendering Index (%)	61-100	63	Yes
Power Density (W/m^2)	<=10.33	5.47	Yes

The ideal number of lamps can be calculated using equation (1). The calculation uses Neon lamps as the reference lamp type because they have higher lumen values and lower power compared to Argon lamps. Data parameters along with the calculation results can be seen in Table 2. Based on Table 2, it is determined that 26 lamps are needed to achieve the standard lighting level. The addition of lamps will affect the power density aspect. The baseline power density is 5.47 watts/m². Upon recalculation with 26 lamps, the power density value increases to 8.65 watts/m². However, this value is still below the maximum limit (10.33 watts/m²), so the power density aspect still falls within the standard category.

Table 2. Parameters for Standard Lighting Calculation

Notation	Description	Value
E	Standard illuminance	350 lux
A	Area of illuminated surface	108.3 m^2
F	Flux luminous of installed lamp (Neon 36 watt)	2850 lumen
Kp	Utilization coefficient	0.56
Kd	Depreciation coefficient	0.9
N	Number of lamp required	26

Another alternative solution that can be considered is replacing the lamp type with LED (Light Emitting Diode). Currently, LED is a type of lamp that has the highest efficacy, around 120 lumens/watt (Department of The Environment and Energy-Australia, 2019). For a lighting requirement of 2,850 lumens, the electrical power needed for each LED lamp is only 24 watts, making it more energy-efficient. However, this replacement needs to consider cost aspects since, in general, LED lamps have a higher market price compared to other lamp types. In addition to adding more lamps, another aspect to consider is the layout of the lamp installations. Figure 6 shows that the layout of lamp installations is not evenly distributed. The number of lamps installed above the visitor table area is insufficient, impacting the potential risk of inadequate visual comfort in the visitor seating area. To address this issue, the study recommends altering the lamp layout as illustrated in Figure 7. Equation (2) is used to determine the spacing between lamps (S). According to (Department of The Environment and Energy-Australia, 2019), the Spacing to Mounting Height Ratio (SHR) for tube-type lamps is recommended to be 2. If the value of H is known to be 3.15 meters, then the value of S can be calculated to be 6.3 meters. Based on this calculation, the recommended spacing between lamps should not exceed 6.3 meters.

3.2. Air Conditioning Evaluation

The next discussion involves the calculation of the cooling load. All parameter values are determined based on observations, temperature measurements, and references from the tables provided by (ASHRAE, 2013). The cooling load is calculated based on a reference room temperature of 77°F (25°C) in August at 2:00 PM local time for the Java Island area. This time is chosen because according to the Meteorology, Climatology, and Geophysics Agency, it is predicted to be the peak of the dry season in the Indonesian region (Warsudi, 2022). Thus, it can be assumed that this time represents the condition when the cooling load requirement is at its highest.

Table 3. Exterior Cooling Load Calculation Parameters

Component	Type/Material	Parameter
South Wall	Common Brick – 4 inch	A =306.6 ft^2; U=0,415 BTU/h ft^2 ºF; CLTDc = 13 ºF
North Wall	Common Brick – 4 inch	A=399.6 ft^2; U=0,415 BTU/h ft^2 ºF; CLTDc = 12 ºF
North Windows	Single glass – wooden frame	A=98.2 ft^2; U=0,9 BTU/h ft^2 ºF; CLTD = 13 ºF
South Windows	Single glass - wooden frame	A=191.2 ft^2; U=0,9 BTU/h ft^2 ºF; CLTD = 13 ºF
Air Infiltration	Medium	CFM=104; ΔT=13 ºF

The parameters for calculating the exterior cooling load can be seen in Table 3. The construction material for the south and north walls is common brick with a thickness of approximately 10 cm or 4 inches. The windows on the north and south sides are made of single glass with a wooden frame. The room partition is considered medium as it is tightly closed but still allows for air infiltration. Cooling load from solar radiation is not calculated because, based on observation, there is no direct sunlight entering the room.

Parameters for calculating the interior cooling load can be seen in Table 4. The roof component is included in the interior category because there is another room above the library that has an air conditioning unit, so the temperature difference is not too large. The type of occupant activity is adjusted to the activities inside the library, which include sitting and light activities (seated-very light work) such as reading or working with a computer.

Table 4. Interior Cooling Load Calculation Parameters

Component	Type/Material	Parameter
West wall	Gypsum partition	A=233.2 ft^2; U=0.31 BTU/h ft^2 °F; ΔT=6 °F
East wall	Masonry-concrete block-	A=291.3 ft^2; U=0.49 BTU/h ft^2 °F; ΔT=5 °F
Ceiling	Heavyweight concrete deck - 6 inch	A=1165.3 ft^2; U=0.28 BTU/h ft^2 °F; ΔT=2 °F
Floor	Concrete- heat flow down	A=1165.3 ft^2; U=0.26 BTU/h ft^2 °F; ΔT=5 °F
Human	Seated- very light work	Qs= 245 BTU/h; Ql=155 BTU/h; N=18 people
Lighting	Gas discharge	P = 592 watt; Fb = 1.25
Appliances	Computer	P = 200 watt; Fp = 1
	Water heater	P = 385 watt; Fp = 1
	Laptop	P = 65 watt; Fp = 1
	Printer	P = 12 watt; Fp = 0.25

The calculation of heat radiation from the installed lamps is given a value of Fb = 1.25 because all lamps are gas discharge type with an additional control circuit inside. All electrical equipment except the printer is given a value of Fp = 1 as they operate almost continuously. Meanwhile, the printer is assigned a value of Fp = 0.25 because it is often in standby mode and rarely used.

A summary of the cooling load calculation results along with the list of equations used can be seen in Table 5. Based on these calculations, the total exterior cooling load (*Qext*) is 8,517 BTU/hour. The largest component of the exterior cooling load comes from the south window, amounting to 2,237 BTU/hour, while the smallest cooling load comes from the north window, amounting to 1,149 BTU/hour. On the other hand, the total interior cooling load (*Qint*) is 15,265 BTU/hour, with the heat radiation from humans contributing the most at 7,200 BTU/hour, and the west wall being the smallest component at 434 BTU/hour. Based on these calculations, the total cooling load is 23,782 BTU/hour. In comparison, the interior cooling load is much larger than the exterior.

Table 5. Cooling Load Calculation Results

Component	Type	Equation	Cooling Load (BTU/h)
South wall	Exterior	(4)	1,654
North wall	Exterior		1,990
North windows	Exterior	(5)	1,149
South windows	Exterior		2,237
Air infiltration	Exterior	(6)	1,487
West wall	Interior	(8)	434
East wall	Interior		714
Ceiling	Interior	(9)	653
Floor	Interior	(10)	1,515
Human	Interior	(11)	7,200
Lighting	Interior	(12)	2,523
Appliances	Interior	(13)	2,227

The library has 2 air conditioning units with a total cooling capacity of 25,000 BTU/hour. The detailed specifications of the air conditioning units can be seen in Table 6. Upon comparison, the total cooling capacity of the installed air conditioning units is greater than the total cooling load, thus it can be concluded that thermal comfort in the library can be achieved.

Table 6. Air Conditioning Unit Specifications

No	Type	Power (Watt)	Cooling Capacity (BTU/h)	EER (BTU/h/Watt)
1	*Split Wall*	1,560	18,000	11.54
2	*Window*	750	7,000	9.33

However, the installed Window-type air conditioning unit has an Energy Efficiency Ratio (EER) below the standard recommended by the regulation (Penerapan Standar Kinerja Energi Minimum Untuk Peralatan Pemanfaat Energi, 2021), which is 10.41. In addition, the lifespan of the air conditioning unit is very long, and the technology used is outdated. It is recommended to replace this unit with a Split Wall type with a capacity of 5,000 BTU/hour. Considering the components of the cooling load, it is recommended that the 18,000 BTU/hour capacity air conditioning unit switch positions with another unit located to the east. This recommendation is based on the fact that the largest component of the cooling load is located on the east side (visitor area).

4. Conclusion

Room comfort is a crucial aspect for libraries in fulfilling their function to support the services of higher education institutions. This research aims to evaluate the comfort of the library space at Politeknik ATMI Surakarta, covering aspects of lighting and air conditioning. The evaluation results are compared with the current applicable standards. Based on the evaluation, it is found that the lighting level needs improvement through the addition of lights and a rearrangement of the lighting installation. Another alternative solution is the replacement of lights with LED types that are more energy-efficient.

The total cooling capacity of the installed air conditioning unit in the room is in line with the cooling load requirements. However, it is recommended to replace the Window-type air conditioning unit with a Split Wall type. Additionally, it is also recommended to switch the position of the 18,000 BTU/hour capacity air conditioning unit to the east for more effective cooling. In the future, the aspect of energy conservation in this study can still be further developed through an assessment of the Energy Consumption Intensity (Balai Besar Teknologi Konversi Energi-BPPT, 2020).

References

Andarini, D., & Listianti, A. N. (2017). Evaluasi Intensitas Pencahayaan (Illumination Level) pada Perpustakaan di Lingkungan Universitas Sriwijaya. *Journal of Industrial Hygiene and Occupational Health*, *2*(1). https://doi.org/10.21111/jihoh.v2i1.872

ASHRAE. (2013). 2013 ASHRAE Handbook - Fundamentals (SI Edition). In *2013 ASHRAE Handbook—Fundamentals (IP)* (Vol. 2013, Issue 38).

Badan Standardisasi Nasional. (2011). SNI 6197: 2011 Konservasi Energi pada Sistem Pencahayaan. *Standar Nasional Indonesia*. https://pesta.bsn.go.id/produk/detail/9024-sni61972011

Balai Besar Teknologi Konversi Energi-BPPT. (2020). *Benchmarking Specific Energy Consumption di Bangunan Komersial*. www.b2tke.bppt.go.id

Biantoro, A. W. (2017). Analisis Perbandingan Efisiensi Energi pada Gedung P Kabupaten Tangerang dan Gedung Tower UMB Jakarta. *Jurnal Teknik Mesin*, *6*(3), 164. https://doi.org/10.22441/jtm.v6i3.1966

Department of The Environment and Energy-Australia. (2019). *A Reference Manual for Training in Efficient Lighting Principles Training Guide: The Basics of Efficient Lighting*. https://www.energyrating.gov.au/industry-information/publications/training-professionals-basics-efficient-lighting

Extrada, E., Muhamadiah, Makomulamin, Satria Efendi, A., & Edigan, F. (2021). Analysis of The Impact of Lighting Pharmacy Lighting Intensity with The Eye of Eye Complaints on Workers in The Mesra Hospital of Kampar District 2020. *Al-Tamimi Kesmas: Jurnal Ilmu Kesehatan Masyarakat (Journal of Public Health Sciences)*, *9*(1), 50–56. https://doi.org/https://doi.org/10.25311/kesmas.Vol1.Iss1.328

Fadhila, A. N., & Santiasih, I. (2021). Kenyamanan Termal dan Faktor Individu yang Mempengaruhi Kejadian Heat Strain pada Pekerja Labelling Canning. *Envirotek: Jurnal Ilmiah Teknik Lingkungan*, *13*(1), 60–65. https://doi.org/https://doi.org/10.33005/envirotek.v12i2.99

Fadhly Adhi Risnandar, F. (2019). Kenyamanan Termal dan Kepuasan Pengguna Ruang Kelas di Gedung Kampus ITSB. In *japps.itsb.ac.id Journal of Applied Science: Vol. I* (Issue 1). www.japps.itsb.ac.id

Konservasi Energi Sistem Tata Udara Bangunan Gedung, Pub. L. No. SNI 03-6390-2020 (2020).

Kurniasih, S., & Saputra, O. (2019). Evaluasi Tingkat Pencahayaan Ruang Baca pada Perpustakaan Universitas Budi Luhur, Jakarta. *Jurnal Arsitektur ARCADE*, *3*(1), 73–79. https://doi.org/https://doi.org/10.31848/arcade.v3i1.136

Kurniawan, R., Santoso, M. E., & Darmayanti, T. E. (2022). Pengaruh Pencahayaan pada Showroom Terhadap Kenyamanan Visual (Studi Kasus Showroom Harley Davidson, Bandung). *Waca Cipta Ruang*, *8*(1), 6–12. https://doi.org/10.34010/wcr.v8i1.6593

Kusumawati, M., & Nugrahaini, F. T. (2021). Identifikasi Standar Kenyamanan Desain Interior pada Perpustakaan Pusat Universitas Muhammadiyah Surakarta. *(SIAR) Seminar Ilmiah Arsitektur*, 185–192.

Munawaroh, A. S., & Elbes, R. (2019). Persepsi Pengguna Terhadap Kenyamanan Termal pada Bangunan Perpustakaan IBI Darmajaya Lampung. *Jurnal Arsitektur Dan Perencanaan (JUARA)*, *2*(2), 175–193. https://doi.org/http://dx.doi.org/10.31101/juara.v2i2.882

Penerapan Standar Kinerja Energi Minimum Untuk Peralatan Pemanfaat Energi, Pub. L. No. 14, PERMEN ESDM (2021). https://jdih.esdm.go.id/storage/document/Permen%20ESDM%20No.%2014%20Tahun%202021.pdf

Peraturan Pemerintah Republik Indonesia Nomor 33 Tahun 2023 Tentang Konservasi Energi, Pub. L. No. 33 (2023).

https://jdih.esdm.go.id/index.php/web/result/2384/detail

Prasetyo, H., Apriliasari, C. A., Suryajaya, G. M., & Pramudita, M. C. A. (2020). Evaluasi Pencahayaan dan Pengkondisi Udara pada Ruang Laboratorium Komputer di Politeknik ATMI Surakarta. *Performa: Media Ilmiah Teknik Industri*, *19*(2). https://doi.org/10.20961/performa.19.2.46281

Rahmayanti, D., & Artha, A. (2016). Analisis Bahaya Fisik: Hubungan Tingkat Pencahayaan dan Keluhan Mata Pekerja pada Area Perkantoran Health, Safety, and Environmental (HSE) PT. Pertamina RU VI Balongan. *Jurnal Optimasi Sistem Industri*, *14*(1), 71. https://doi.org/10.25077/josi.v14.n1.p71-98.2015

Renaldi, A., Purnama, D., Sutrisno, M., & . M. (2019). Rekayasa Ulang Sistem Pencahayaan dan Pengkondisian Udara pada Gedung Magister Sains Terapan Politeknik Negeri Bandung. *Potensi : Jurnal Sipil Politeknik*, *21*(1), 1–9. https://doi.org/10.35313/potensi.v21i1.1310

Rezka Adi, A. (2019). Optimalisasi Pencahayaan Alami pada Ruang Perpustakaan Universitas Islam Negeri Walisongo Semarang. *Jurnal Arsitektur Komposisi*, *13*(1), 35–44. https://doi.org/https://doi.org/10.24002/jars.v13i1.2780

Setyaningsih, E., Zureidar, I., & Arifandi, L. (2021, December 16). *Peduli Energi Melalui Revisi SNI Konservasi*. https://money.kompas.com/read/2021/12/16/142855626/peduli-energi-melalui-revisi-sni-konservasi

Suhardi, B. (2015, May 27). Audit Energi Untuk Pencahayaan pada Bangunan Gedung Perpustakaan Universitas Sebelas Maret. *Workshop dan Seminar Nasional Energi Indonesia*.

Talarosha, B. (2005). Menciptakan Kenyamanan Thermal dalam Bangunan. In *Jurnal Sistem Teknik Industri* (Vol. 6, Issue 3).

Tri Wahyu, B. (2019). *Audit Energi Listrik dan Analisis Peluang Penghematan Konsumsi Energi Listrik pada Sistem Pendingin dan Pencahayaan di Gedung D3 Ekonomi UII* [Undergraduate]. Universitas Islam Indonesia.

Warsudi, E. (2022, March 24). *Prakiraan Musim Kemarau Tahun 2022 di Indonesia*. https://www.bmkg.go.id/berita/?p=prakiraan-musim-kemarau-tahun-2022-di-indonesia&lang=ID&s=detil

Performa: Media Ilmiah Teknik Industri
ISSN 1412-8624 (print) | ISSN 2620-6412 (online)
Vol. 24, No. 1, 2025, Page. 1-10
doi.org/10.20961/performa.24.1.72432

AUTHORS METADATA

I. **First Author*:**

1. First name : Hoedi
2. Middle Name :
3. Last Name : Prasetyo
4. E-mail : hoedi.prasetyo@atmi.ac.id
5. Orcid ID : 0000-0002-6279-7065
6. Orcid URL : https://orcid.org/0000-0002-6279-7065
7. Affiliation : Mechatronics Study Program, Politeknik ATMI Surakarta
8. Country : Indonesia
9. Bio Statement :
10. Phone Number :

II. **Second Author**

1. First name : Nicholas Lucky
2. Middle Name :
3. Last Name : Baskara
4. E-mail : nicholas.20202037@student.atmi.ac.id
5. Orcid ID :
6. Orcid URL :
7. Affiliation : Mechatronics Study Program, Politeknik ATMI Surakarta
8. Country : Indonesia
9. Bio Statement :
10. Phone Number :

III. **Third Author:**

1. First name : Bayu
2. Middle Name :
3. Last Name : Saputro
4. E-mail : bayu.20202011@student.atmi.ac.id
5. Orcid ID :
6. Orcid URL :
7. Affiliation : Mechatronics Study Program, Politeknik ATMI Surakarta
8. Country : Indonesia
9. Bio Statement :
10. Phone Number :

IV. **Fourth Author:**

1. First name : Matius
2. Middle Name : Damar Adi
3. Last Name : Pradhana
4. E-mail : matius.20202034@student.atmi.ac.id
5. Orcid ID :
6. Orcid URL :
7. Affiliation : Mechatronics Study Program, Politeknik ATMI Surakarta
8. Country : Indonesia
9. Bio Statement :
10. Phone Number :