

Analysis of the Suitability of Air Conditioning Capacity in the Civil Engineering Workshops at Polytechnic Kuching Sarawak

Lukman Nul Hakim Md Terasid^{1*}, Muhammad Iqmal Qusyairie Mazlan², Anis Mastura R Azmi¹

¹Department of Civil Engineering, Politeknik Kuching Sarawak, KM 22, Jalan Matang, 93050, Kuching, Sarawak, Malaysia

²Department of Mechanical Engineering, Politeknik Kuching Sarawak, KM 22, Jalan Matang, 93050, Kuching, Sarawak, Malaysia

*Corresponding author: lukman@poliku.edu.my

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Abstract

This study was carried out to analyze the suitability of air-conditioning capacity for the cooling load of Civil Engineering workshop at Polytechnic Kuching Sarawak. The study was conducted because an unsuitable air-conditioning capacity may result in inefficient energy use, higher operating costs, and reduced system performance. The objectives were to determine the cooling load based on internal heat sources, evaluate the performance of the existing air-conditioning units using operating parameters, and assess whether the installed capacity is suitable for the workshop spaces. The study used a quantitative approach through direct measurements conducted in seven workshops at the Department of Civil Engineering, Polytechnic Kuching Sarawak. Data was collected on the number of occupants, lighting, computers, printers, room volume, current, voltage, and the Coefficient of Performance (COP). The results showed that the cooling load differed according to the size of the workshop and the amount of internal heat generated. Most of the air-conditioning units achieved acceptable COP values. However, the installed capacity in most workshops was found to be higher than the actual cooling load, indicating an overcapacity condition. Overall, the findings suggest that reviewing the installed air-conditioning capacity could improve energy efficiency, reduce unnecessary energy consumption, and provide a more suitable indoor environment for workshop users.

Keywords: - Air-conditioning capacity, internal heat load, energy efficiency

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1. Introduction

Air-conditioning systems play an important role in maintaining thermal comfort, occupant productivity and indoor environmental quality in educational facilities. Consequently, air-conditioning system represent one of the largest contributors to electricity consumption in educational buildings, making proper capacity selection essential for both energy efficiency and operational effectiveness.

Previous studies have examined building energy consumption across various building categories including

office buildings, commercial buildings and educational facilities with particular attention to energy use associated with heating and air-conditioning systems (Zarco-Soto et al., 2025). However, existing research has largely examined energy consumption at the general building level with limited attention given to the suitability of air-conditioning capacity in technical education workshops. Unlike conventional classrooms, technical workshop may exhibit different cooling demand characteristics due to variations in occupant density, practical activities, specialised room functions and the presence of heat-generating equipment. Therefore, assessing the suitability of installed air-conditioning capacity in technical

education workshops is necessary to identify potential mismatches between cooling requirements and installed capacity, thereby supporting improved energy efficiency and operational performance.

2. Background of Study

The building sector is one of the major consumers of energy worldwide with air-conditioning systems contributing significantly to overall electricity consumption. In Malaysia's hot and humid climate, educational institutions rely heavily on air-conditioning systems to maintain thermal comfort and provide conducive learning environments. Consequently, improving the efficiency of air-conditioning systems has become an important strategy for reducing energy consumption and supporting sustainable building management (International Energy Agency, 2022).

Previous studies have investigated cooling load estimation, HVAC performance and energy consumption in educational buildings and other building categories (Zarco-Soto et al., 2025). Although these studies have enhanced the understanding of building energy use, most have focused on general building-level assessments and conventional learning spaces such as classrooms. Limited attention has been given to technical education workshops, where cooling requirements may differ due to practical activities, occupancy patterns, room functions and equipment-related heat generation.

In addition, existing studies commonly evaluate cooling demand through cooling load calculations or energy consumption analysis without examining whether the installed air-conditioning capacity is suitable for the actual cooling requirements of the space (Ortega-Diaz et al., 2025). This limitation creates a research gap in understanding the adequacy of air-conditioning capacity in technical education workshops. According to American Society of Heating, Refrigerating and Air-Conditioning Engineers (2021), the selection of an appropriate air-conditioning capacity depends on several factors including internal heat gains, ventilation requirements, room size and occupant density. Internal heat gains generated by occupants, lighting systems and electrical equipment are among the key contributors to cooling demand. However, these factors are rarely evaluated in relation to the installed capacity of existing air-conditioning systems. Consequently, limited information is available on whether air-conditioning systems in technical education workshops are appropriately sized to meet cooling requirements while maintaining energy-efficient operation.

To address this gap, the present study evaluates the suitability of installed air-conditioning capacity in seven Civil Engineering workshops at Polytechnic Kuching Sarawak, which represent the entire population of air-conditioned workshops within the Department of Civil Engineering. Unlike previous studies that primarily focused on cooling load estimation or general energy consumption analysis, this study examines the relationship between internal heat gains and the installed capacity of

existing air-conditioning systems in actual workshop settings. By evaluating all air-conditioned workshops within the department, this research extends existing knowledge beyond general air-conditioning assessments and provides practical evidence to support more effective energy management and air-conditioning system planning in technical education facilities.

3. Problem Statement

Air-conditioning systems are essential for maintaining thermal comfort and indoor environmental quality, particularly in technical education institutions where workshop spaces are intensively used and internal heat gains are relatively high. According to American Society of Heating, Refrigerating and Air-Conditioning Engineers (2021), the selection of an appropriate air-conditioning capacity should be based on the cooling requirements of the conditioned space to ensure efficient and optimal system performance. In Malaysia, HVAC systems are among the major contributors to building energy consumption, highlighting the need for effective capacity selection and energy management. Furthermore, educational facilities typically experience substantial cooling demand due to occupancy, equipment usage and extended operating hours (Zarco-Soto et al., 2025).

Previous studies have focused on cooling load estimation, HVAC performance and energy consumption in educational buildings (Ortega-Diaz et al., 2025). However, these studies generally evaluate building energy performance without determining whether the installed air-conditioning capacity is appropriate for the cooling requirements of specific spaces. As a result, limited information is available regarding the suitability of installed air-conditioning capacity in technical education workshop environments.

In addition to cooling capacity suitability, the operational performance of existing air-conditioning systems is also important in determining their efficiency. Parameters such as current, voltage, power consumption and Coefficient of Performance (COP) provide useful information on the operating condition and energy performance of the installed systems.

In technical education workshops, internal heat gains generated by occupants, lighting systems, and electrical equipment contribute significantly to cooling demand. However, internal heat gains should not be considered equivalent to the actual cooling load of a building, as external heat gains, ventilation requirements, infiltration, and building envelope characteristics may also influence the total cooling load (American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2021). Therefore, an assessment based on internal heat gains provides an indication of cooling demand but does not represent a complete cooling load analysis.

The seven Civil Engineering workshops at Polytechnic Kuching Sarawak are equipped with air-conditioning systems, however, no assessment has been conducted to determine whether the installed cooling capacities are

appropriate for the cooling requirements generated within these spaces. Therefore, this study evaluates the suitability of the existing air-conditioning capacity by examining internal heat-gain-based cooling requirements and the operating performance of the installed air-conditioning systems. The findings are expected to support more efficient energy management and improve air-conditioning system planning in technical education facilities.

4. Objective

The objectives of this study are:

1. To estimate the cooling demand of selected Civil Engineering workshops based on internal heat gain sources including occupants, lighting systems and electrical equipment.
2. To evaluate the operational performance of the existing air-conditioning systems using measured operating parameters such as current, voltage, power consumption and Coefficient of Performance (COP).
3. To determine the suitability of the installed air-conditioning capacities by comparing the available cooling capacity with the estimated internal heat-gain-based cooling requirements of the workshop spaces.

5. Literature Review

5.1 Cooling Requirement and Heat Gains

Cooling requirements refer to the amount of heat that must be removed from a conditioned space to maintain the desired indoor temperature and thermal comfort (American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2021). The cooling requirements of a space are influenced by several factors including occupants, lighting systems, electrical equipment, ventilation, infiltration and building characteristics (McDowall, 2007). Among these factors, internal heat gains generated within the conditioned space are important because they directly increase the amount of heat that must be removed by the air-conditioning system (Pedersen et al., 1998).

Recent studies have highlighted the influence of internal heat gains on energy consumption in educational buildings. Ortega-Diaz et al. (2025) reported that occupancy was one of the most influential factors affecting air-conditioning energy consumption in classrooms located in a tropical climate. The study further showed that the use of electrical equipment contributed significantly to cooling demand and building energy consumption. Similarly, Zarco-Soto et al. (2025) emphasized that HVAC systems constitute a substantial portion of building energy consumption, and that cooling-related energy use is strongly influenced by space utilisation and operational conditions.

In the Malaysian context, Ismail et al. (2018) evaluated indoor air quality in air-conditioned classrooms and laboratories at Politeknik Merlimau based on temperature and carbon dioxide (CO₂) concentration measurements. The study found that indoor temperatures ranged between

22°C and 26.5°C, while CO₂ concentrations were generally within acceptable limits. However, the research focused primarily on indoor environmental quality and did not evaluate cooling requirements, installed air-conditioning capacity or system operating performance.

Although previous studies have improved understanding of energy consumption and indoor environmental conditions in educational buildings, limited attention has been given to the suitability of installed air-conditioning capacity in technical education workshops. Furthermore, internal heat gains should not be considered equivalent to the actual cooling load because external heat gains, ventilation requirements, infiltration, and building envelope characteristics also contribute to the total cooling load of a building (American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2021). Therefore, this study focuses on estimating cooling requirements based on internal heat gains rather than conducting a comprehensive cooling-load analysis.

5.2 Air-Conditioning System Performance

Air-conditioning system performance refers to the ability of a system to provide adequate cooling while operating efficiently and maintaining acceptable indoor thermal conditions (Silberstein et al., 2020). The performance of an air-conditioning system is commonly evaluated using operating parameters such as current, voltage, power consumption, and the Coefficient of Performance (COP), which provide information regarding system efficiency and operating condition (Jabatan Alam Sekitar, 2020).

Current and voltage measurements are important indicators of system operation because they are used to determine electrical power consumption and identify abnormal operating conditions (Jabatan Alam Sekitar, 2020). Excessive current draw may indicate increased cooling demand, equipment deterioration or system inefficiencies, while unstable voltage may negatively affect equipment performance and service life (Silberstein et al., 2020).

Another commonly used indicator of HVAC efficiency is the Coefficient of Performance (COP), which represents the ratio between cooling output and electrical energy input (Cengel et al., 2019). A higher COP indicates greater system efficiency because more cooling is produced per unit of energy consumed (Cuce, 2026). Consequently, COP has been widely adopted as a practical indicator for evaluating the energy performance of air-conditioning systems.

While previous studies have focused primarily on energy consumption prediction and indoor environmental quality, fewer studies have assessed the operating performance of existing air-conditioning systems in relation to their installed capacity and space cooling requirements. Therefore, this study utilises current, voltage, power consumption and COP measurements to evaluate the operational performance of air-conditioning systems installed in Civil Engineering workshops.

5.3 Air-Conditioning Capacity Suitability

Air-conditioning capacity refers to the cooling capability of an air-conditioning system to remove heat from an indoor space and maintain the required temperature for thermal comfort (American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2021). It is generally expressed in British Thermal Units per hour (BTU/hr) or kilowatts (kW) and represents an essential parameter in determining the appropriate cooling capacity during HVAC system design and equipment selection.

Selecting an appropriate air-conditioning capacity is essential for maintaining thermal comfort and achieving energy-efficient operation (Chartered Institute of Building, 2023). An undersized air-conditioning unit may operate continuously without achieving the desired indoor temperature, whereas an oversized unit may experience short cycling, resulting in reduced operating efficiency and increased maintenance requirements (McDowall, 2007). Appropriate equipment sizing has also been shown to improve energy efficiency and overall HVAC performance (Cuce, 2026).

Despite extensive studies on cooling-load estimation and HVAC energy consumption, research evaluating the suitability of installed air-conditioning capacities in technical education workshops remains limited. Most previous studies have focused on estimating cooling loads, predicting energy consumption or assessing indoor environmental quality without determining whether the installed cooling capacity adequately matches the cooling requirements of the space. This limitation has created a gap in understanding the adequacy of installed air-conditioning systems in workshop-based educational environments.

To address this gap, the present study evaluates the suitability of installed air-conditioning capacities in seven Civil Engineering workshops at Polytechnic Kuching Sarawak. Unlike previous studies, this study relates internal heat-gain-based cooling requirements to installed cooling capacity and air-conditioning system performance, thereby providing a more comprehensive assessment of capacity suitability in technical education facilities.

5.4 Comparison of Previous Study

Table 1 shows that previous studies have primarily focused on indoor environmental quality, energy consumption, and general HVAC energy performance. Although these studies provide valuable information regarding thermal comfort and energy use in educational buildings, they do not evaluate whether the installed air-conditioning capacity is suitable for the cooling requirements of technical education workshop spaces.

Furthermore, the relationship between internal heat-gain-based cooling requirements and installed air-conditioning capacity has received limited attention in previous research. Therefore, the present study extends existing knowledge by integrating internal heat-gain assessment with air-conditioning system performance

evaluation to determine the suitability of installed air-conditioning capacity in Civil Engineering workshops at Polytechnic Kuching Sarawak.

Table 1: Comparison between previous studies and the contribution of the present study

Title	Research Focus	Main Findings
Kajian Terhadap Kualiti Udara Dalam Bilik Kuliah di Politeknik Merlimau (Ismail et al., 2018)	Assessment of indoor air quality in air-conditioned classrooms and laboratories based on temperature and CO ₂ concentration.	The study focused on indoor environmental quality and thermal comfort.
Performance of Energy Consumption Prediction Techniques in Classrooms of an Educational Building in a Warm Tropical Climate (Ortega-Diaz et al., 2025)	Prediction of air-conditioning energy consumption in educational buildings	The study focused on energy-consumption prediction rather than cooling-capacity assessment.
Energy Consumption in Buildings: Current Knowledge and Sustainability Perspectives (Zarco-Soto et al., 2025)	Analysis of building energy consumption and the contribution of HVAC systems to overall energy use.	This study highlights the importance of improving energy efficiency and system operation.
Present study	Evaluation of internal heat-gain-based cooling requirements, air-conditioning system performance, and installed cooling-capacity suitability in Civil Engineering Workshop at Polytechnic Kuching Sarawak	Assesses the suitability of installed air-conditioning capacity by relating internal heat gains, current, voltage, power consumption, and COP to workshop cooling requirements.

6. Scope and Limitations of Study

This study focuses on evaluating the suitability of the installed air-conditioning capacities in meeting the estimated cooling requirements of workshop spaces at Polytechnic Kuching Sarawak. The scope covers seven selected workshops within the Department of Civil Engineering (JKA) that are equipped with air-conditioning systems. The cooling demand of each workshop is estimated based on internal heat gain sources, including room dimensions, number of occupants, lighting systems, and electrical equipment such as computers and printers. These factors are considered to determine the estimated cooling requirements of the respective workshop spaces.

In addition, the study evaluates the operational performance of the existing air-conditioning systems through measurements of electrical current, operating voltage, and power consumption. The Coefficient of

Performance (COP) is also determined to assess the cooling performance of the systems in relation to their electrical power input. Furthermore, the specifications of the installed air-conditioning units including rated capacity in horsepower (HP) and cooling capacity in British Thermal Units per hour (BTU/hr) are collected to determine their available cooling capacities. These capacities are then compared with the estimated cooling requirements of the workshop spaces to assess the suitability of the installed systems.

However, this study is limited to the assessment of internal heat gains and the operational performance of the existing air-conditioning systems. External factors affecting the total cooling load such as outdoor ambient temperature, solar heat gain, air infiltration, ventilation requirements and building envelope characteristics are not included in the cooling demand estimation. Therefore, the estimated cooling demand represents an assessment based on internal heat gains rather than a comprehensive cooling load calculation. The findings are used to determine whether the installed air-conditioning capacities are appropriate, undersized or oversized in relation to the estimated cooling requirements of the selected workshop spaces.

7. Methodology

This study uses a quantitative research approach to assess the suitability of the existing air-conditioning capacities in meeting the estimated cooling requirements of workshop spaces at Polytechnic Kuching Sarawak. The study involves direct field measurements, collection of technical specifications and engineering calculations to evaluate the cooling demand and operational performance of the existing air-conditioning systems. To ensure a systematic and structured research process, the methodology is divided into three main stages comprising four phases: (i) collection of workshop physical data, (ii) collection of air-conditioning operational data, (iii) collection of air-conditioning specification data, and (iv) data recording and organization. These phases are designed to support the achievement of the three research objectives.

7.1 Research Design

This is a field-based study that involves gathering physical data straight from the workshop itself. The information was obtained through direct observation, taking measurements with specialized tools, and running calculations based on standard air conditioning formulas

7.2 Research Location

The study was conducted across seven Civil Engineering workshops at Polytechnic Kuching Sarawak that rely on air conditioning systems for space cooling.

7.3 Research Instruments

The following instruments were utilized to carry out the study:

- i. Clamp Meter: Used to measure the electrical current while the air conditioning systems were actively running.
- ii. ThermoProbe/Digital Thermometer: Used to record the return air, supply air, and ambient room temperatures.
- iii. Distance Measuring Tool: Used to measure the length, width, and height of the spaces to accurately calculate room volume.
- iv. Data Collection Form: Used to log spatial details, occupant numbers, lighting, computers, printers, and the technical specifications of each AC unit.

7.4 Data Collection Procedure

The data collection for this study was carried out in distinct phases aligned with the research objectives, ensuring that all gathered information was both accurate and systematically recorded.

a) Phase 1: Collection of workshop physical data

The initial phase of the study involved direct site observations and physical measurements of the selected workshop spaces. The dimensions of each air-conditioned workshop, including its length, width, and height, were measured to determine the total room volume. In addition, data on all internal heat sources within the workshops were collected, specifically:

- i. The number of occupants using space
- ii. The number of lighting fixtures installed
- iii. The number of computers in use
- iv. The number of printers located within the room

Current readings were taken using a clamp meter on the outdoor unit, as this section houses the primary components that consume the highest amount of electrical energy. The electrical input power in kilowatts (kW) was then calculated. Depending on the system's electrical supply, equations (1) and (2) were applied.

$$\text{Single-Phase Systems } P_{in} = \frac{V \times I \times PF}{1000} \quad (1)$$

$$\text{Three-Phase Systems } P_{in} = \frac{\sqrt{3} \times V \times I \times PF}{1000} \quad (2)$$

Where V is the measured voltage, I is the measured current, and PF is the power factor. A power factor of 0.85 was utilized, which accurately represents the inductive load typical of standard workshop compressor motors under normal operating conditions.

The power consumption for lighting and electrical equipment was obtained directly from their specification labels. In cases where labels were missing, standard industry reference values were applied based on the equipment type. Specifically, the heat load for lighting was calculated using the actual wattage listed on the fixtures installed in the observed spaces. If a label was unavailable, we relied on industry standards according to the specific bulb type (e.g., 9–24W for LEDs and 36–40W for

fluorescent lights). Based on this, the following values were established:

- i. LED Lamp = 9W, 18W, 24W
- ii. Fluorescent lamps = 36W
- iii. Conventional fluorescent lamps = 40W

The heat load for printers was determined based on the actual power rating found on the equipment's specification label or the manufacturer's manual. If this data was unavailable, reference values from manufacturer specifications were used depending on the specific printer type (inkjet or laser).

- i. Inkjet printer → ±20–50W
- ii. Small laser printer → ±300–600W
- iii. Large/multi-function laser printer → ±600–1500W
- iv. Standby mode → ±5–30W

b) Phase 2: collection of air conditioning operational data

During the second phase, we measured the actual performance of the existing air conditioners in the workshops. We took these readings while the units were running normally to ensure the data reflected real operational conditions. The parameters we recorded were:

- i. The electrical current during operation
- ii. The voltage of the AC system

To estimate the initial cooling load for each space, a standard rule-of-thumb method based on room volume (W/m) was applied. While some literature references floor-area methods, the volume-based approach was selected for this study as it better accounts for the varied and often elevated ceiling heights present in the workshop and laboratory environments. The estimated cooling load (Q) was calculated as in equation (3).

$$Q_{load} = V \times q_v \quad (3)$$

Current readings were taken using a clamp meter on the outdoor unit, as this section houses the primary components that consume the highest amount of electrical energy. We estimated the initial cooling load for each space using a standard rule-of-thumb method based on floor area (W/m^2) following the recommendations of the American Society of Heating, Refrigerating and Air-Conditioning Engineers and general HVAC industry guides. The cooling load benchmarks by room type are:

- i. 30–40 W/m^3 → Office / ordinary room
- ii. 40–60 W/m^3 → Computer room / light workshop
- iii. 60–80 W/m^3 → Space with high occupancy / equipment density
- iv. 80–120 W/m^3 → Hot space / high cooling load

c) Phase 3: Collection of air conditioning specification data

During the third phase, we gathered the technical details of the air conditioning units by checking the specification labels right on the equipment. We recorded the following information:

- i. Unit capacity in horsepower (HP)
- ii. Cooling capacity in BTU/hr
- iii. Operating voltage
- iv. The operating current stated by the manufacturer

This specification data allowed us to compare the equipment's output with the actual cooling load of each space. We took the manufacturer's BTU/hr value and converted it into kW so it could be easily measured against the room's real heat load. In the Malaysian and Asian markets, manufacturers such as Daikin Industries issue model specifications that clearly show how HP corresponds to cooling capacity:

- i. HP ≈ 9,000 BTU/hr ≈ 2.6 kW
- ii. 1.5 HP ≈ 12,000 BTU/hr ≈ 3.5 kW
- iii. 2.0 HP ≈ 18,000 BTU/hr ≈ 5.3 kW
- iv. 2.5 HP ≈ 24,000 BTU/hr ≈ 7.0 kW
- v. 3.0 HP ≈ 30,000 BTU/hr ≈ 8.8 kW

We assessed how efficient the air conditioning systems are by looking at their COP values, keeping in mind that a higher COP means better overall energy efficiency (American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2021)

- i. COP > 4 = Excellent
- ii. COP 3–4 = Good
- iii. COP 2–3 = Moderate
- iv. COP < 2 = Inefficient / requires inspection

d) Phase 4: Data recording and organization

All obtained data were recorded into data collection sheets according to the specific workshop spaces under study. The data was organized into the following categories:

- i. Physical characteristics of space
- ii. Internal heat sources
- iii. Air conditioning operational data
- iv. Air conditioning capacity data

This structured arrangement aims to streamline the analysis process for determining the suitability of the air conditioning capacities relative to the actual cooling requirements of the workshop spaces.

8. Findings

8.1. Estimating the Workshop Cooling Demand Based on Internal Heat Sources

Based on the data presented in Table 2, the estimated cooling demand of the seven selected workshops was assessed by considering their physical characteristics and internal heat gain sources. The parameters included room volume, number of occupants, lighting fixtures, computers, and printers. These factors were considered because they contribute to heat generation within the workshop spaces. Room volume was determined by measuring the length, width, and height of each workshop, while the number of occupants and electrical equipment was recorded through direct observation. The information collected provides an overview of the internal heat gain conditions and cooling requirements of each workshop. However, the estimated values represent cooling demand based on internal heat gains only and do not account for external factors such as solar heat gain, ventilation, air infiltration, and building envelope characteristics.

Table 2: Cooling demand for each workshop

Workshop Area / Space Heat Load Basis	Occupants 120w	Lights 40w	Computers 150w	Printers 300w	Room Volume (m ³) 40w	Qload Total Heat
1. Building Services Workshop						
Supervisor's Room	3	3	4	1	80	3.2 kW
Storage Room	-	2	-	-	44	1.8 kW
2. Carpentry Workshop						
Storage Room	-	2	-	-	40	1.7 kW
3. Concrete Workshop						
Supervisor's Room	2	2	2	-	48	2.5 kW
4. Surveying Workshop						
Supervisor's Room	2	2	2	2	36	2.5 kW
5. Geotechnical and Highway Laboratory						
Student Project Gallery	-	4	-	-	90	3.8 kW
Supervisor's Room	2	2	2	2	51	3.3 kW
6. Photogrammetry Laboratory						
Supervisor's Room	3	4	3	2	75	4.6 kW
Study Area 1	-	7	-	-	75	3.3 kW
Study Area 2	-	5	-	-	104	4.4 kW
7. Cartography Laboratory						
Study Area 1	47	6	1	-	192	13.7 kW
Computer Room	40	9	40	-	186	18.6 kW

As shown in Table 2, each room has a different cooling demand depending on its size and the amount of internal heat generated by occupants, lighting, and electrical equipment. Rooms with a higher number of occupants and heat-producing equipment, particularly computers, require greater cooling capacity. For example, the Cartography Lab Computer Room recorded the highest cooling load of 18.6 kW due to its high occupancy and intensive computer usage. On the other hand, storage rooms require much less cooling because there is barely any activity or equipment running in them. Ultimately, as internal heat sources increase, so does the demand for the air conditioning system's cooling load.

8.2 Evaluating the Performance of Existing Air Conditioning Units Based on Operational Parameters

Table 3 displays the current AC units' performance using measured parameters like capacity, voltage, electrical current, and COP. We used this data to evaluate exactly how efficiently the air conditioners in the workshops are running.

Fig. 1 illustrates the comparison between the installed air conditioning capacity and cooling load for each workshop space combining the data on Table 2 and Table 3. It shows that the installed cooling capacity varies across the selected spaces with some units having capacities that exceed the estimated cooling load. This comparison provides an overview of the suitability of the installed air-conditioning capacities in meeting the estimated cooling requirements of each workshop.

Based on Table 3, the performance of the air conditioning units can be evaluated using the calculated Coefficient of Performance (COP) values for each workshop. Most of the units recorded COP values above

3.0, indicating that the air conditioning systems are operating efficiently and providing satisfactory cooling performance. The higher the COP value, the more efficiently the system uses electricity to cool down the room. That being said, a few units logged lower COP scores than the rest, which suggests their performance might be dropping, or they are due for a service. Overall, the results show that most of the air conditioners in the workshops are still operating at a perfectly satisfactory level.

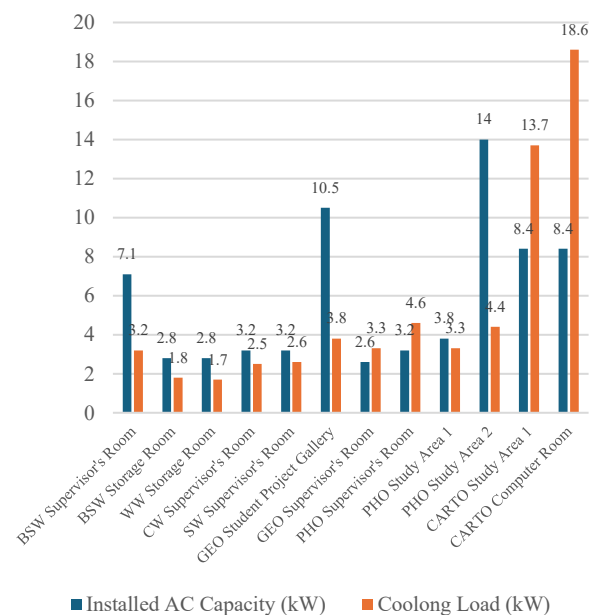


Fig. 1: Installed AC capacity and cooling load

Table 3: Current AC units’ performance

Workshop Area/ Space	Qac - Capacity Aircond	Power Input		COP (Coefficient of Performance) COP = Qcooling / P
	(Watt)	Voltage (240v / 415v)	Current (I)	
	2.0HP $\approx$ 18,000 BTU/hr 1 BTU/hr $\approx$ 0.293 W			
1. Building Services Workshop				
Supervisor's Room	7100		Amp = 11.88 P = 2423.5	2.93
Storage Room	2780		Amp = 3.82 P = 779.3	3.57
2. Carpentry Workshop				
Storage Room	2800		Amp = 3.21 P = 654.8	4.27
3. Concrete Workshop				
Supervisor's Room	3208		Amp = 3.44 P = 701.8	4.57
4. Surveying Workshop				
Supervisor's Room	3208		Amp = 4.85 P = 989.4	3.24
5. Geotechnical and Highway Laboratory				
Student Project Gallery	10500		Amp = 3.31 P = 3476.5	3.02
Supervisor's Room	2640		Amp = 2.79 P = 569.2	4.64
6. Photogrammetry Laboratory				
Supervisor's Room	3208		Amp = 3.43 P = 699.7	4.58
Study Area 1	3810		Amp = 5.21 P = 1062.8	3.58
Study Area 2	14000		Amp = 3.91 P = 4136.2	3.38
7. Cartography Laboratory				
Study Area 1	8445		Amp = 10.8 P = 2203.2	3.03
Computer Room	8445		Amp = 10.8 P = 2203.2	3.03

Table 4: Comparison of existing air conditioning capacity and cooling load requirements

Workshop Area/ Space	* Determination of Air Conditioner Capacity Suitability QAC = Actual cooling capacity of the air conditioner (W) Qload = Total cooling load of the room (W)	Assessment	Unit operates efficiently and effectively.	Capacity is appropriate, but the COP is low, indicating reduced operating efficiency.	Cooling capacity is insufficient.	The unit capacity is oversized for the room cooling requirement.	The unit is old, has a low COP, and provides insufficient cooling capacity.
		COP	>3	<2.5	-	>3	<2
		R	1.00-1.10	1.00-1.10	<1.00	>1.10	<1.00
	<i>Undercapacity</i> R < 1.00 Suitable capacity R = 1.00 – 1.10 <i>Overcapacity</i> R > 1.10	Recommended Action	Continue using the existing unit.	Carry out service and preventive maintenance.	Upgrade to a higher-capacity air conditioning unit.	Replace with a unit of a more appropriate (smaller) capacity.	Replace with a new air conditioning unit.
1. Building Services Workshop							
Supervisor's Room	2.22					/	
Storage Room	1.54					/	
2. Carpentry Workshop							
Storage Room	1.65					/	
3. Concrete Workshop							
Supervisor's Room	1.28					/	
4. Surveying Workshop							
Supervisor's Room	1.23					/	
5. Geotechnical and Highway Laboratory							

Student Project Gallery	2.76	/
Supervisor's Room	0.80	/
6. Photogrammetry Laboratory		
Supervisor's Room	0.70	/
Study Area 1	1.15	/
Study Area 2	3.18	/
7. Cartography Laboratory		
Study Area 1	0.62	/
Computer Room	0.45	/

* We figured out if the capacities were suitable by comparing the unit's cooling output to the room's actual heat load, making sure to include a 10% design margin.

8.3 To Determine The Suitability of Existing Air Conditioning Capacity to Meet The Cooling Load Requirements of The Workshops Space

As shown in Table 4, the suitability of the installed air-conditioning capacities was evaluated by comparing the rated cooling capacities with the estimated cooling demand of each workshop. This comparison aims to determine whether the installed air-conditioning units are appropriately sized, undersized, or oversized in relation to the estimated cooling requirements of the respective spaces.

Based on Table 4 and Fig. 2, most of the workshops were found to have oversized air-conditioning capacities, indicating that the installed units provide cooling capacity exceeding the estimated cooling requirements of the respective spaces. However, two workshops, namely the Photogrammetry Lab Supervisor Room and the Cartography Lab Computer Room, were identified as having undersized air-conditioning capacities, where the available cooling capacity is insufficient to meet the estimated cooling demand. These findings highlight the importance of reassessing the installed air-conditioning capacities to ensure appropriate system sizing, improve energy efficiency, and minimise potential energy wastage.

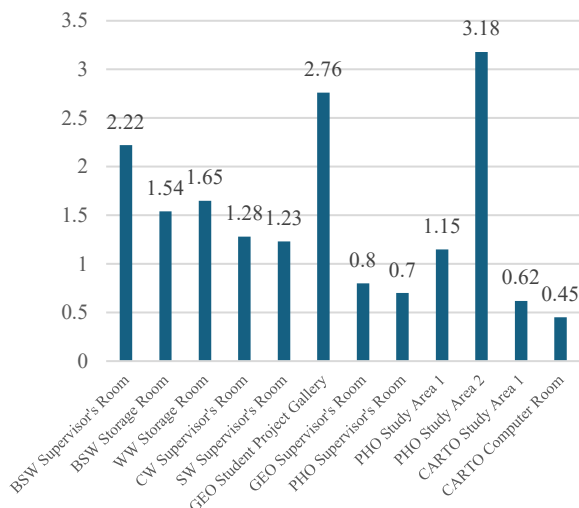


Fig. 1: Air conditioning capacity suitability ratio across workshop spaces

9. Conclusion

Our results clearly show that most of the workshop spaces suffer from overcapacity, where the air conditioning units are much too large for the actual cooling needs. This issue stems from the fact that older systems were often installed using rough rule-of-thumb estimates and weren't adjusted when the rooms were repurposed. On top of that, using modern, energy-efficient appliances has actively reduced the internal heat load in these spaces. Leaving AC units in an overcapacity state drives up energy waste and causes short cycling, which ruins efficiency. Reevaluating these capacities is a necessary step to stop wasting electricity and make the workshops more comfortable for users. For future studies, researchers should investigate how window openings and natural ventilation affect heat gain or loss in the workshops. This is important because how windows are used dictates how much outside heat and airflow enters the room, directly impacting the AC's cooling load. Future work should also include a detailed breakdown of room temperature and humidity to better evaluate thermal comfort. Doing so will help clarify whether the current AC systems can sustain the right environmental conditions for these workspaces.

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