

**MAINTENANCE OF HEATING, VENTILATION & AIR-
CONDITIONING (HVAC) SYSTEM AND ITS USER
SATISFACTION: A COMPARISON BETWEEN
ACADEMIC BUILDINGS IN IIUM GOMBAK**

BY

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**A dissertation submitted in fulfilment of the requirements for
the degree of Master of Science (Asset and Facilities
Management)**

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ABSTRACT

A constructed building and its system are expected to undergo wear and tear throughout its design lifespan. Hence, building maintenance is significant to ensure the building and its system can serve its function properly and preserve its value and appearance. Therefore, this research is conducted to identify the Heating, Ventilation and Air-Conditioning (HVAC) system's maintenance management and the related problems. In addition, the research seeks to identify the perceived level of user satisfaction with the maintenance of the HVAC system in the academic buildings in IIUM Gombak and strategies to improve user satisfaction. The study focuses on two perspectives which are the user and the maintenance management of the HVAC system for two academic buildings which are Ahmad Ibrahim Kulliyyah of Law (AIKOL) and Kulliyyah of Information and Communication Technology (KICT) in International Islamic University Malaysia (IIUM) Gombak. Hence, this research adopted a questionnaire survey and semi-structured interview as the method of data collection. In total, 100 valid responses from the survey and seven interview sessions were analysed and discussed. The findings show that both academic buildings used centralised and decentralised HVAC systems. The maintenance activities categorised under predictive, preventive and corrective maintenance strategies were practised for the HVAC system in academic buildings with an average of monthly and three-month frequency. Meanwhile, insufficient budget for maintenance, insufficient skills and knowledge of the maintenance staff, lack of expertise for the maintenance works, improper maintenance database, maintenance management issues and poor quality of maintenance spare parts and materials were found as the problems related to the maintenance of the HVAC system in the academic buildings. Moreover, the respondents were satisfied with the thermal comfort, acoustical comfort, indoor air quality, ability to control indoor temperature, safety, serviceability and operational management as the factors associated with user satisfaction in academic buildings. Furthermore, upgrade the maintenance management system with current trends and technologies, continuous improvement on the technique of maintenance management, frequent monitoring and inspection, enhance the communication among the key participants, provide a proper maintenance database, upgrade the staff competencies and ensure the sufficient resources for maintenance were found as the appropriate strategies to improve the user satisfaction on the maintenance of the HVAC system. Hence, this research presents the direction for further research aimed at improving the maintenance of academic buildings.

Keywords: Maintenance Management, HVAC System, Academic Building

ملخص البحث

من المتوقع أن يتعرض المبنى المشيد ونظامه للتآكل طوال العمر الافتراضي لتصميمه. ومن ثم فإن صيانة المباني مهمة لضمان أداء المبنى ، كما أن نظامه يمكن أن يؤدي وظيفته على نحو سليم ويحافظ على قيمته ومظهره. ومن هنا فإن هذا البحث أجري لتحديد إدارة الصيانة في نظام التدفئة والتهوية وتكييف الهواء والمشاكل ذات الصلة. بالإضافة إلى ذلك ، يسعى البحث إلى تحديد المستوى المتصور لرضا المستخدم عن صيانة نظام HVAC في المباني الأكاديمية في IIUM Gombak واستراتيجيات تحسين رضا المستخدم. وتركز الدراسة على منظورين هما المستخدم وإدارة الصيانة لنظام HVAC لمبنيين أكاديميين هما أحمد إبراهيم كلية القانون (AIKOL) وكلية تكنولوجيا المعلومات والاتصالات (KICT) في جامعة الإسلامية العالمية ماليزيا (IIUM) في Gombak. ومن ثم اعتمد هذا البحث استبيانا استقصائيا ومقابلة شبه منظمة كأسلوب لجمع البيانات. وفي المجموع جرى تحليل ومناقشة 100 إجابة صالحة من الدراسة الاستقصائية وسبع جلسات لإجراء المقابلات. وتبين النتائج أن كلا المبنيين الأكاديميين يستخدمان أنظمة HVAC المركزيين واللامركزيين. تمت ممارسة أنشطة الصيانة المصنفة تحت استراتيجيات الصيانة التنبؤية والوقائية والتصحيحية لنظام HVAC في المباني الأكاديمية بمعدل تواتر شهري وثلاثة أشهر. وفي الوقت نفسه تبين أن الميزانية غير كافية للصيانة وعدم كفاية المهارات والمعرفة لدى موظفي الصيانة والافتقار إلى الخبرة الفنية اللازمة

لأعمال الصيانة وقاعدة بيانات الصيانة غير السليمة ومسائل إدارة الصيانة وسوء جودة قطع الغيار ومواد الصيانة ، هي مشاكل تتصل بصيانة نظام HVAC في المباني الأكاديمية. وعلاوة على ذلك أعرب المجيبون عن ارتياحهم للراحة الحرارية والراحة الصوتية ونوعية الهواء في الأماكن المغلقة والقدرة على التحكم في درجة الحرارة في الأماكن المغلقة والسلامة وقابلية الخدمة وإدارة العمليات بوصفها عوامل مرتبطة برضاء المستعملين في المباني الأكاديمية. بالإضافة إلى ذلك تحسين نظام إدارة الصيانة مع الاتجاهات والتكنولوجيات الحالية والتحسين المستمر لتقنية إدارة الصيانة والمراقبة المتكررة والتفتيش وتعزيز الاتصال فيما بين المشاركين الرئيسيين وتوفير قاعدة بيانات مناسبة للصيانة ؛ وقد وُجد أن تحسين كفاءات الموظفين وضمان توفير الموارد الكافية للصيانة هما الاستراتيجيتان المناسبتان لتحسين رضا المستعملين عن الإبقاء على نظام HVAC. و بالتالي فإن هذا البحث يعرض الاتجاه نحو إجراء المزيد من البحوث الرامية إلى تحسين صيانة المباني الأكاديمية.

الكلمات المفتاحية : إدارة الصيانة ، نظام التكييف ، المبنى الأكاديمي

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science (Asset and Facilities Management)

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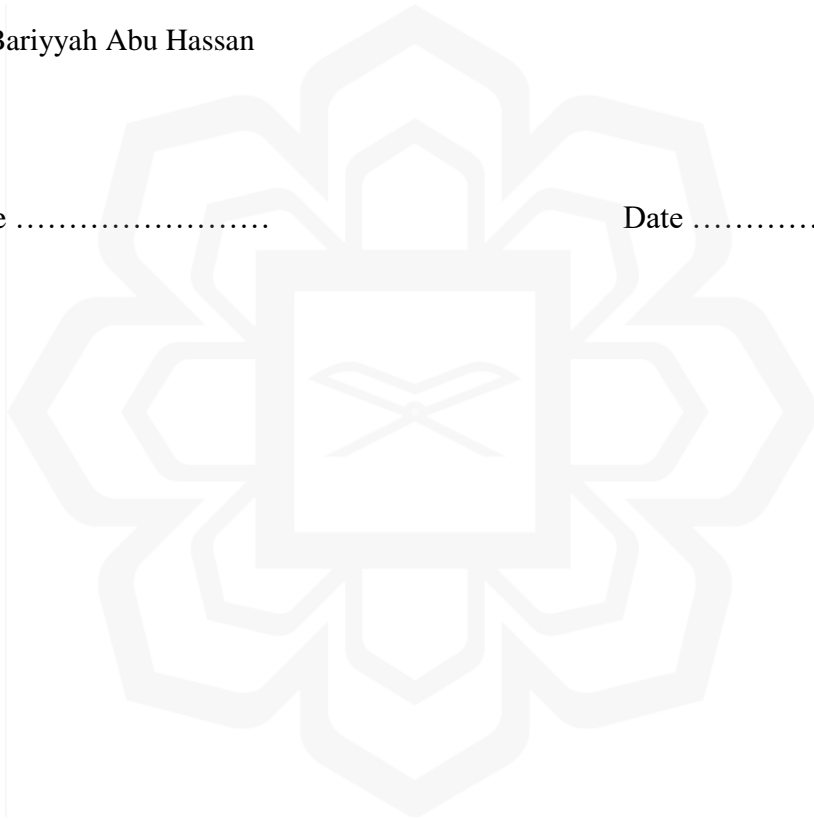
DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degree at IIUM or other institutions.

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LIST OF ABBREVIATIONS

AIKOL	Ahmad Ibrahim Kulliyyah of Law
BSC	Balanced Score Card
CMMS	Computerised Maintenance Management System
CSM	Customer Satisfaction Measurement
DBSB	Daya Bersih Sdn Bhd
HVAC	Heating, Ventilation & Air-Conditioning
IAQ	Indoor Air Quality
IIUM	International Islamic University of Malaysia
KICT	Kulliyyah of Information and Communication Technology
KPI	Key Performance Indicator
LCC	Life Cycle Cost
POE	Post Occupancy Evaluation
PWD	The Public Works Department
SBS	Sick Building Syndrome
SLA	Service Level Agreement
VBP	Value Based Performance
VRV	Variable Refrigerant Volume System

CHAPTER ONE

INTRODUCTION TO THE RESEARCH

1.1 INTRODUCTION

This chapter provides an overview of the research entitled "Maintenance of HVAC System and Its User Satisfaction: A Comparison Between Academic Buildings in IIUM Gombak".

This chapter shall cover as follows:

- i. Background of the study
- ii. Problem Statement
- iii. Research Questions
- iv. Research aim and objectives
- v. Scope of research
- vi. Research Methodology
- vii. Significance of research
- viii. Structure of Dissertation

1.2 BACKGROUND OF STUDY

Maintenance is the most crucial period that constitutes almost 95% of the building life after the construction period (Amani et al., 2012). According to Hashim and Mydin, (2012), maintenance is a set of activities to improve the facilities or restore them to their desirable condition. Meanwhile, according to Lateef (2010), maintenance is defined as the necessary processes and services commenced to care for a building structure and its services after its completion to retain its current standards that will enable the building to serve its required purpose throughout its lifespan without significantly interrupting the essential features and functions. According to Amani et al. (2012), maintenance of buildings and their systems is one of the most crucial aspect of building management for all types of buildings, including academic buildings.

A building and its facilities are assets with a high value depending on its quality and maintenance frequency (Lateef et al., 2010). Among the building types that can be considered a significant asset not for the individual but for the government itself is university. In addition, Lateef et al. (2010) stated that a university or higher educational institution is a place that is procured to build a suitable, conducive, and sufficient environment for learning, teaching, and research. As added by them, failure to provide these vital services for university mainly academic building will make it less valuable to the university, the community, the students, the faculty, and other. This is because academic buildings are so important to the higher educational institution as they serve the primary function of providing a comfortable environment conducive to teaching, learning, and research activities. It has also become one of the facilities often occupied by the students and the lecturers (Muhammad et al., 2014 & Abisuga et al., 2016).

Besides, the comfortability of the academic building is not solely relying on the proper maintenance of its outer building performance but also the thermal comfort of the academic building (Khalil et al., 2012). As supported by Au-Yong et al. (2014), in this situation, the HVAC system is the most important building service that helps increase the level of the occupants' productivity and comfort and determine the quality of air inside the building. As added by them, the heat, ventilation, and air conditioning (HVAC) system can be defined as a system that provides adequate ventilation and air circulation in a building. It may serve one or more areas of the building. according to its type. Mohamad et al. (2018) stated that the primary function of an HVAC system is to assure thermal comfort and air quality for the occupants. Hence, many considerations are needed to adjust the HVAC system for both the academic building and its occupants to achieve the standard level of comfort and satisfaction.

Accordingly, the effectiveness of academic building's maintenance can be measured through the users' satisfaction, nature of defects and maintenance performance metrics for the academic buildings (Lateef et al., 2010). This is important because students and lecturers spend a significant amount of time in academic buildings for various teaching and learning activities (Khalil et al., 2012). Hence, all buildings, including academic buildings and their services, are prone to wear and tear, which will reduce their performance over time, and this will worsen the conditions if the maintenance activities are insufficient

(Abisuga et al., 2016). Therefore, the good maintenance system for academic building and its HVAC system is important as it is where the main activities of teaching and learning are being conducted, and it plays a vital role in the deliverable of academic activities, student's academic performance, the comfort and satisfaction of the users. As such, it is interesting to study the maintenance management of the HVAC system in academic buildings. The following section discusses the research problem that justifies the rationale for this study.

1.3 PROBLEM STATEMENT

Maintenance is an activity that intends to conserve, preserve, manage and regulate buildings, facilities, and services to meet the institution's current standards, functions, values, and security (Nawi et al., 2017). However, maintenance problems for buildings in Malaysia are common regardless of the size and owners of the buildings (Lateef, 2009). As cited by Zakiyudin et al. (2014), the list of buildings that faced inadequate maintenance in Malaysia are countless. Zakiyudin et al. (2014) mentioned that one of the root causes of this problem is the lack of understanding of the maintenance process among building management teams that hinder the production of good maintenance programs. As stated by Zakiyudin et al. (2014), the inexistence of systematic maintenance management in most of the buildings and facilities in Malaysia always results in over-budgeting the costs for maintenance and remedial work.

Moreover, Nawi et al. (2017) found that there are also many problems regarding poor maintenance, poor maintenance culture and lack of work ethic among the maintenance team that lead to accidents and injuries. As asserted by Lateef (2009), building maintenance procedures in Malaysia are ineffectual, and most procedures are reactive in nature. According to Yong and Sulieman (2015), indicated that the practices of maintenance for academic building in Malaysia should be improved because most of the education department are more depending on reactive and condition-based maintenance practice that often lead to the higher chance of breakdown of the building elements. Moreover, there are also many maintenance issues faced by higher education in Malaysia due to poor service delivery, insufficient funding, poor maintenance plan and maintenance backlogs (Ismail & Kasim, 2013).

As added by Ismail and Kasim (2013), some higher education institutions still use improper databases and implement the conventional methods in the maintenance management system which they used the paper-based form to provide defect reports from students and staff which these normally cause the irregularities in the maintenance management system at the university. According to Saghatforoush et al. (2011), the conventional method in managing the maintenance also often leads to technical and managerial defects such as lack of technical expertise to operate and supervise building facilities using new technology, improper work planning, inefficient data recording systems, failure to identify potential defects and specify the correct remedial work, economic and financial defects. Moreover, Khalil et al. (2012) mentioned that there are also many maintenance problems for higher education institutions that focus on the outer appearance of the building and the system and services.

This is supported by Gang et al. (2015) and Mohamad et al. (2018) that the poor maintenance of centralised HVAC system in the building always lead to the increasing in cost to operate the cooling process and the maintenance cost to enhance the performance of the system. In addition to that, the demand for the proper maintenance of HVAC systems is getting increased not only due to the rising cost of operation and maintenance but also to the ever-increasing cost of energy (Nawi et al., 2017). Moreover, it is common that the HVAC system's poor maintenance contributes to the maximum energy consumption in most commercial buildings (Bhanware et al., 2020). According to previous study that the HVAC system contributes the highest in energy consumption as it can exceed more than 50% of the total energy consumption of a building (Chua et al., 2013 & Nawi et al., 2017).

Furthermore, there are also cases of inefficient operation and maintenance of the HVAC system that caused Sick Building Syndrome (SBS) (Au-Yong et al., 2014). As Abisuga et al. (2016) elaborated, SBS is associated with air humidity and thermal comfort in indoor environments that are mainly caused by poor maintenance of HVAC systems, which is dangerous to the users' health. Furthermore, as cited by Au-Yong et al., (2014), it is common that the improper maintenance of HVAC systems leads to the issue of poor indoor air quality, which has disastrous consequences for human health. The poor indoor environment of the building will affect user's productivity and make the indoor areas uncomfortable for users due to heat and a high concentration of carbon dioxide (Abisuga et

al., 2016 & Churazova, 2019). Hence, the maintenance for the building and its system in Malaysia can be classified as in dissatisfaction level and must be tightened up to keep the building and its system healthy and able to function properly. This should be applied to the academic building as well because the proper performance and functions of the place for teaching, learning, and conducting the research will reflect the wellbeing and quality of education in Malaysia.

A previous study by Nawi et al. (2017) has covered maintenance and management issues in Malaysian commercial building towards sustainable future practice. Meanwhile, a study by Au-Yong et al. (2014) has focused on effective maintenance management of HVAC systems in office buildings. Another study conducted by Yong and Sulieman (2015) has discovered the building maintenance management practice and occupant satisfaction of school buildings. Research by Mohamad et al. (2018) has focused on strategic management for operation and maintenance costs of the HVAC system in the university office. Overall, it can be concluded that all this research still does not address the details on the maintenance of HVAC systems for the academic buildings at the university. Hence, there are significant gaps in the body of knowledge in this area. Accordingly, this study seeks to investigate the maintenance of the HVAC system and user satisfaction with the case study of academic buildings in International Islamic University of Malaysia (IIUM) Gombak.

1.4 RESEARCH QUESTIONS

This research seeks to answer these important questions:

1. What is the maintenance management of the HVAC systems implemented for the academic buildings?
2. What are the problems related to the maintenance of the HVAC systems for the academic buildings?
3. What is the perceived level of user satisfaction with the maintenance of the HVAC systems of academic buildings?
4. What are the appropriate strategies to improve user satisfaction on the maintenance of HVAC systems in academic buildings?

1.5 AIM AND OBJECTIVES

This research aims to study the maintenance of the HVAC systems between AIKOL and KICT academic buildings at the International Islamic University of Malaysia. Accordingly, the research objectives are:

1. To examine the maintenance management of the HVAC systems in academic buildings.
2. To investigate the problems related to the maintenance of the HVAC systems for academic buildings.
3. To identify the level of user satisfaction of the maintenance of the HVAC systems of academic buildings.
4. To propose appropriate strategies to improve user satisfaction on the maintenance of the HVAC systems in academic buildings.

1.6 SCOPE OF RESEARCH

This research only covers the scope of maintenance of the HVAC systems and its user satisfaction between AIKOL and KICT academic buildings at the International Islamic University Malaysia, Gombak.

1.7 RESEARCH METHODOLOGY

Research methodology can be defined as the specific procedures or techniques used to identify, select, process, and analyse information about a topic. Several approaches were planned for this study to attain the research aim and objectives. Thus, the methodology will be divided into three main parts:

- i) Primary data collection
- ii) Secondary data collection
- iii) Data analysis