Retrofitting Project for Improved Chiller System Performance in a Hotel, Kuala Lumpur, Malaysia

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DECLARATION

I declare that this thesis entitled “Retrofitting Project for Improved Chiller System Performance in a Hotel, Kuala Lumpur, Malaysia” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Refrigeration And Air-Conditioning System) with Honours.

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DEDICATION

In the name of Allah, the Most Beneficial, the Most Merciful. Nothing can ever be achieved without His will for letting it to happen.

This report is dedicated to my wonderful parents, Razak bin Hj Lajis and Fauziah binti Hj Nuralhadi, who have always loved me unconditionally and whose excellent examples have inspired me to work hard for what I want. This work is also dedicated to my colleagues from this WBL program who have travelled this path with me and have been an ongoing source of support and inspiration as I have struggled through graduate school and everyday life issues.

ABSTRACT

This thesis addresses the pressing issue of energy inefficiency in commercial buildings, with a specific focus on the hotel industry, by investigating the impact of aging chiller systems. In response to the heightened environmental awareness, this research aims to contribute to sustainable practices through a comprehensive retrofitting project at the Sheraton Imperial Hotel Kuala Lumpur. The objectives include analyzing current chiller system inefficiencies, measuring improvements post-retrofitting, and evaluating economic feasibility. The methodology involves a preliminary energy audit, chiller selection considerations, and financial assessments. The retrofitting initiative, involving the replacement of the aging 19XR chiller with a Carrier 23XRV water-cooled chiller and Variable Frequency Drive (VFD) technology, demonstrates a remarkable 54% improvement in chiller plant efficiency. Financial analyses indicate a profitable venture with an expected annual electricity bill decrease, a payback period of 4.064 years, and a substantial return on investment (ROI) of 25%. The success of this retrofitting project not only establishes the Sheraton Imperial Hotel as a leader in operational excellence and environmental responsibility but also provides valuable insights for similar initiatives in the hospitality sector. Continuous monitoring and future research efforts are recommended to ensure long-term performance improvements and to inspire the adoption of sustainable practices throughout the industry.

ABSTRAK

Tesis ini menangani isu mendesak ketidakcekapan tenaga dalam bangunan komersial, dengan tumpuan khusus pada industri hotel, dengan menyiasat kesan sistem penyejuk yang semakin tua. Sebagai tindak balas kepada peningkatan kesedaran alam sekitar, penyelidikan ini bertujuan untuk menyumbang kepada amalan mampan melalui projek pengubahsuaian yang komprehensif di Hotel Sheraton Imperial Kuala Lumpur. Objektif termasuk menganalisis ketidakcekapan sistem penyejuk semasa, mengukur penambahbaikan selepas pemasangan semula, dan menilai kebolehlaksanaan ekonomi. Metodologi ini melibatkan audit tenaga awal, pertimbangan pemilihan penyejuk dan penilaian kewangan. Inisiatif pengubahsuaian, yang melibatkan penggantian penyejuk 19XR yang sudah tua dengan penyejuk penyejuk air Carrier 23XRV dan teknologi Pemacu Frekuensi Berubah (VFD), menunjukkan peningkatan 54% yang luar biasa dalam kecekapan loji penyejuk. Analisis kewangan menunjukkan usaha niaga yang menguntungkan dengan jangkaan penurunan bil elektrik tahunan, tempoh bayaran balik 4.064 tahun dan pulangan pelaburan (ROI) yang besar sebanyak 25%. Kejayaan projek pengubahsuaian ini bukan sahaja menjadikan Hotel Sheraton Imperial sebagai peneraju dalam kecemerlangan operasi dan tanggungjawab alam sekitar tetapi juga memberikan pandangan berharga untuk inisiatif serupa dalam sektor hospitaliti. Pemantauan berterusan dan usaha penyelidikan masa depan disyorkan untuk memastikan peningkatan prestasi jangka panjang dan untuk memberi inspirasi kepada penggunaan amalan mampan di seluruh industri.

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LIST OF SYMBOLS AND ABBREVIATIONS

HVAC	-	Heating, Ventilating, Air-Conditioning
VFD	-	Variable Frequency Drives
CHWP	-	Chilled Water Pump
CDWP	-	Condenser Water Pump
CT	-	Cooling Tower
kW	-	Kilowatt Power
RT	-	Refrigerant tonnes
kWh	-	Kilowatt hour
ROI	-	Return on Investment

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CHAPTER 1

INTRODUCTION

1.1 Background

Heating, ventilation, and air conditioning (HVAC) systems rely on refrigeration equipment, like vapor compression chillers, to maintain comfortable temperatures in occupied spaces. The annual building operating cost is directly impacted by their energy performance. Many technologies have been introduced over the years as a result of the intense competition among manufacturers and the growing demand for refrigeration equipment. Making the best choice is challenging due to the large range of refrigeration equipment that is available (Solati et al., 2003).

In Malaysia, where tropical and humid weather prevails, air conditioning within a building is essential for the resident comfort. When we can use air-cooled devices to cool tiny rooms, the cooling capacity in bigger infrastructures may easily expand by tenfold (Tracey, 2010). Because the expense of an air-cooled unit for such a big cooling capacity cannot be fulfilled, chillers are used to satisfy larger cooling capacity at a cheaper cost.

Chiller systems are required to maintain perfect conditions for a wide range of industrial operations, to regulate interior temperature, and to provide comfort to residents. As the world tries to solve concerns caused by climate change and natural resource depletion, there is an increasing need to assess and improve the performance of these systems. The use of a chiller system to cool big residential or commercial buildings has grown widespread since it is more convenient for the user to concentrate the air conditioning equipment in one area rather than installing multiple pieces of separate equipment in different locations (Pérez-Lombard et al., 2008a)

Chiller systems are an essential component of an HVAC system and have long been used to deliver cooling via centralised air conditioning. Chiller are classified into two types which is air-cooled and water-cooled. The distinction between the two categories essentially dictates how heat is rejected from the system. Water-cooled chillers rely on cooling towers to transfer heat into the atmosphere, whereas air-cooled chillers blast air over their condenser (Evans, 2020)

However, chillers are one of the main energy users in central air conditioning systems. In commercial buildings, where air-conditioning systems account for about half of total power use, chillers are the single largest consumers. As a result, their efficiencies have a substantial impact on the total energy efficiency of these structures (Jayamaha, 2007). HVAC systems have typically been associated with high energy use and a significant rise in a building's carbon footprint according to Energy5. Additionally, it was stated that, as Figure 1.1 illustrates, pumps and chillers account for 21% of all operating expenses.

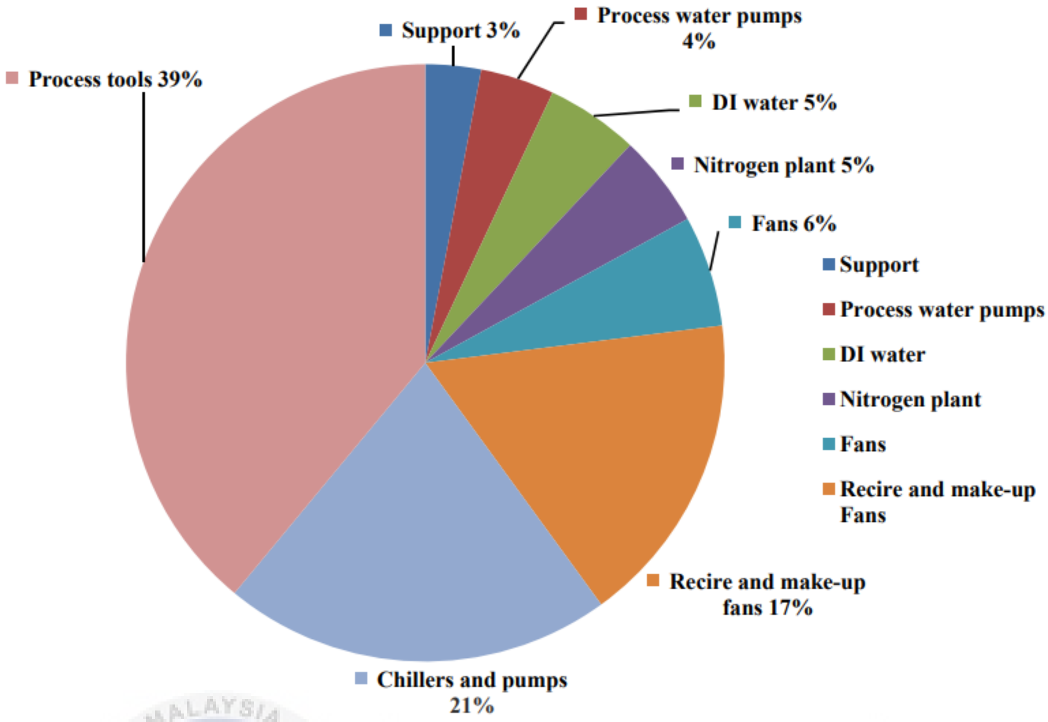

Figure 1.1 Magnitude of operating cost of end uses equipment in a semi-conductor industry (Yogesh, 2004)

With the rising energy consumption of buildings in recent years, energy-saving retrofitting of existing structures has become an essential aspect of building energy-saving research. Inefficient HVAC system design will waste more needless energy, resulting in increased greenhouse gas emissions, particularly from Malaysian power plants that rely heavily on coal and natural gas burning. As a result, it is critical to enhance the efficiency of HVAC systems in order to limit their harmful influence on the environment.

One of the most important economic sectors in the world today is still the tourist industry. Regardless unpredictable crises, tourism has grown steadily, indicating its strength and resilience, according to the World Tourism Organization (UNWTO). Several studies in hotels proved that HVAC systems consume a significant amount of energy. According to (Bohdanowicz & Martinac, 2007), the HVAC systems utilized 50% of the energy in a sample of 184 chosen hotels. Research by (Acosta et al., 2016) studied electrical use in two tropical hotels and discovered that chillers accounted for up to 61% and 48% of total energy consumption, respectively. As a result, hotel energy reductions in HVAC systems are critical.

1.2 Problem Statement

In today's era of increased awareness of the environment, there is growing worry about energy use in commercial facilities, particularly in the hotel industry. Aging chiller systems in these structures are acknowledged as major contributors to the increase in energy consumption. This research intends to address the greater issue of inefficiencies associated with aged chillers, noting its influence on total energy usage in commercial buildings. The goal is to assess the efficiency of current chiller systems and launch a complete retrofitting campaign. By doing so, the project aims to address not just current energy-related concerns, but also to provide insights into sustainable practices for commercial buildings in general.

1.3 Project Objective

The main aim of this project is to enhance the overall energy efficiency and sustainability of the chiller system at Sheraton Imperial Hotel Kuala Lumpur through a comprehensive retrofitting strategy. Specifically, the objectives are as follows:

a) To analyze the inefficiencies in the current chiller system that impact energy consumption and environmental at the hotel building.

b) To measure the improvements in energy efficiency resulting from the retrofitting interventions.

c) To assess the economic feasibility of the retrofitting project by calculating the potential return on investment (ROI) and payback period.

1.4 Scope of Project

The scope of this research are as follows:

- The retrofit project will focus on a hotel in Kuala Lumpur, emphasizing a detailed assessment of the chiller system located within the designated chiller plant room and rooftop areas..
- The project will primarily involve the in-depth analysis of the chiller system's performance efficiency, including individual component efficiencies such as the chiller, chilled water pump, condenser water pump, and cooling tower.
- Compare the efficiency data between the existing chiller system and the newly retrofitted chiller system.
- Analyze the energy and economic savings resulting from the retrofitting interventions on the overall HVAC system operation

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The goal of this chapter is to discuss and evaluate the HVAC chiller research, as well as its system improvement and energy savings. Before the discussion begins, an outline of the evolution of HVAC chillers throughout history will be reviewed. This section will give context for understanding the development and progress of research on this issue. This study will investigate the key theoretical frameworks and ideas that have contributed to how researchers now understand HVAC chillers system optimization and energy savings towards a healthy building. This chapter will also go into the history and materials of HVAC chillers, as well as instances of methodologies utilized in previous research, as well as their advantages and disadvantages.

2.2 Heating Ventilating Air-Conditioning (HVAC)

Heating, ventilation, and air conditioning (HVAC) has been used for decades to create acceptable temperature conditions in enclosed spaces in a variety of settings including residential, industrial, space, and transportation (i.e., the automobile sector). These days, most of us live with HVAC, particularly in tropical and subtropical areas of the world. The US Environmental Protection Agency (EPA) states that an HVAC system's primary functions are to offer thermal comfort and support the maintenance of acceptable indoor air quality (IAQ) through appropriate ventilation and filtration. HVAC can therefore provide comfort for humans (Olesen & Brager, 2004). However, HVAC systems are among the major energy users in buildings and are crucial to the occupant comfort (Vakiloroaya et al., 2014). Research indicates that HVAC systems use between 40 and 60 percent of the energy used in buildings (Pérez-Lombard et al., 2008), which equates to 15% of the energy consumed globally (Rafique & Rehman, 2018). The maintenance of indoor thermal comfort conditions contributes to over half of the energy consumption in commercial buildings (Enteria & Mizutani, 2011). Concern over how much energy heating, ventilation, and air conditioning (HVAC) systems use is rising (Ligade & Razban, 2019). An investment in an energy-efficient HVAC system may provide major benefits to any building. An energy-efficient HVAC system may give several benefits, ranging from decreased energy bills to enhanced indoor air quality according to Hembree Heating & Air Conditioning.

2.3 Types of Chillers in HVAC Systems

A chiller (cooling water circulation device) is a broad name for a device that regulates temperature by circulating a liquid such as water or a heat medium as a cooling liquid, the temperature of which is controlled by the refrigerant cycle. It is used for air conditioning in buildings and industries, as well as controlling the temperature of different industrial devices and laboratory instruments, equipment, and apparatus. It is known as a "chiller" since it is frequently used for chilling according to Panasonic. A fluid or refrigerant is circulated by the condenser, compressor, expansion valve, and evaporator found in all chillers. A chiller's operation is intended to change refrigerant from a liquid to a vapor and back again. The refrigerant takes the heat out of a process while it is in its vapor state. Heat is recovered from a process or operation and recirculated through the system when the compressor and condenser restore it to its liquid state.

According to Industrial Quick Search (IQS), chillers come in a variety of forms, and each one removes heat using a unique method. Air or water is the cooling medium used in all chillers. For instance, a water-cooled chiller uses a cooling tower to circulate water, but an air-cooled chiller system uses fans to cool the water. Even though there are many different types of chillers, most of them remove heat using the same concept. The coolant, also known as the refrigerant, is a crucial component of the process since it helps to maintain steady temperatures by holding onto more heat than either air or water. Chillers differ from one another in addition to the two chilling methods by the kind of compressor they use. Every chiller's compressor serves the same purpose: before the refrigerant enters the condenser, it is compressed to raise its temperature and pressure. There are several ways in which the compressor accomplishes its job.

2.3.1 Air-Cooled Chiller

When there is no issue with discharge, an air-cooled chiller is utilized. It takes up heat from the water and releases it into the atmosphere. Cooling towers are not necessary when using air-cooled chillers. According to Panasonic, this kind of system uses air to cool the refrigerant by sending wind to the heat exchanger. Because air-cooled chillers do not require water, they are frequently favored, particularly in areas where water is limited or prohibitively costly (Wieman, 2019). The chiller has a built-in fan motor that is simple to install, but in confined areas, exhaust equipment could be necessary since exhaust heat is produced in the room. The sizes of packaged air-cooled chillers generally range from 7.5 to 500 tons [25 to 1,580 kW] (Wieman, 2019).

From the article by HVAC Investigators (n.d), the process of Air-Cooled Chiller begins with the primary return delivers warm water to the chiller unit. Heat transfer happens within the evaporator when heated water interacts with the refrigerant, and the now-cooled water passes through the primary supply to properly chill the specified space. The refrigerant passes through the compressor to increase pressure and temperature before reaching the condenser. Here, fans circulate outside air through the condenser, where external fans assits