SOLAR THERMAL IMPLEMENTATION FOR AN ENERGY EFFICIENT COMMERCIAL BUILDING

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I declare that this thesis entitled *"Solar Thermal Implementation for An Energy Efficient Commercial Building"* is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

The power generation has risen significantly due to the constant energy demand. Emphasizing this, several initiatives have been taken to consume energy efficiently in order to reduce energy demand. Buildings that could contribute in sufficing their energy demand by utilizing renewable energy would help reduce the amounts of Carbon Dioxide (CO_2) produced by the building. Hence, technological approach could succeed in developing an energy efficient building. The objective of this report is to obtain a clear idea of energy efficiency comprising of renewable energy implementation in commercial buildings. Moreover, reducing greenhouse gas (GHG) emissions to the environment for further improve sustainability of the world. The solar thermal collector is very commonly used to extract energy from sunlight. The energy efficiencies of the solar collector were analysed at different models depending on the collector area available for the solar collector. Therefore, energy efficiency curves for the solar thermal collector were presented. The energy demand for the system were calculated based on the experimental values for the overall system. Based on the tested models, the most efficient model was identified through sensitivity analysis between collector area and solar thermal yield. The highest and lowest solar yield achieved is 1,516 MWh/a and 0.798 MWh/a respectively. The system overall energy efficiency was determined ranging to be 90-95% for all models. This study can assist in selecting a proper solar thermal collector and storage size for buildings of various capacity and possible improvement in the design of the system components.

ABSTRAK

Penjanaan kuasa telah meningkat dengan ketara berikutan permintaan tenaga berterusan. Menekankan ini, beberapa inisiatif telah diambil untuk menggunakan tenaga secara efisien untuk mengurangkan permintaan tenaga. Oleh itu, teknologi dapat membangunkan sebuah bangunan yang cekap tenaga. Objektif laporan ini adalah untuk mendapatkan idea yang jelas tentang kecekapan tenaga yang terdiri daripada pelaksanaan tenaga boleh diperbaharui dalam bangunan komersial. Selain itu, pengurangan pelepasan kesan rumah hijau (GHG) kepada alam sekitar untuk meningkatkan lagi kemampanan dunia. Pengumpul haba solar sangat biasa digunakan untuk mengeluarkan tenaga dari cahaya matahari. Kecekapan tenaga dianalisis pada model yang berbeza bergantung kepada kawasan pengumpul yang tersedia untuk pengumpul suria. Oleh itu, kecekapan tenaga untuk pengumpul haba solar telah dibentangkan. Permintaan tenaga untuk sistem dikira berdasarkan nilai eksperimen untuk keseluruhan sistem. Berdasarkan model yang diuji, model yang paling berkesan dikenalpasti melalui analisis kepekaan antara kawasan pemungut dan hasil haba solar. Hasil solar tertinggi dan paling rendah dicapai ialah 1,516 MWh/a dan 0.798 MWh/a. Kecekapan tenaga keseluruhan sistem ditentukan antara 90-95% untuk semua model. Kajian ini boleh membantu dalam memilih pemungut haba dan penyimpanan haba solar yang sesuai untuk bangunan pelbagai kapasiti dan peningkatan yang mungkin dalam reka bentuk komponen sistem.

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LIST OF ABBREVIATION

LCOH	-	Levelized Cost of Heat
ROI	-	Return of Investment
SHIP	-	Solar Heating for Industrial Process
EE	-	Energy Efficiency
LEAP	-	Long-Range Energy Alternatives Planning System
GHG	-	Green House Gases

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Energy is the most pre-eminent for improving quality of life through social development and economic growth for all the countries. It has been a significant necessity to almost all industrial and commercial consumers to sustain daily requirement. Energy have two sources which are renewable and non-renewable energy. Malaysia is well equipped with both renewable and non-renewable source. Fossil fuels are the most consumed non-renewable energy while renewable energy such as hydro, solar and biomass are on development progress. These fossil fuels are depleting due to excessive usage. Malaysia's highest electricity source are from fossil fuels which is coal. Figure 1.1 shows the production capacities from different energy source.

Energy source	total in Malaysia	percentage in Malaysia	percentage in Europe	per capita in Malaysia	per capita in Europe
Fossil fuels	225.48 bn kWh	78,0 %	49,2 %	7,130.04 kWh	8,119.98 kWh
Nuclear power	0.00 kWh	0,0 %	7,0 %	0.00 kWh	1,154.95 kWh
Water power	52.03 bn kWh	18,0 %	24,1 %	1,645.39 kWh	3,979.46 kWh
Renewable energy	11.56 bn kWh	4,0 %	19,7 %	365.64 kWh	3,276.27 kWh
Total production capacity	289.08 bn kWh	100,0 %	100,0 %	9,141.08 kWh	16,499.23 kWh

Figure 1.1: Production Capacities from Different Energy Source.

S. (2014). Energy consumption in Malaysia. Retrieved from https://www.worlddata.info/asia/malaysia/energy-consumption.php

Consumption of fossil fuels impacts negatively towards environment primely increasing emissions of greenhouse gases (GHG). These has contributed to global warming which causes environmental imbalance. If this persist, mankind would be the cause for the extinction of non-renewable energy sources and global environmental issues. Immediate measures should be taken to overcome this issue. Figure 1.2 shows the development of CO_2 emissions. There are three main electricity consumers which are domestic, commercial and industries. All requires electricity as a daily requirement for improving their life as well as business profits. These consumers require a substitute renewable energy source so the consumption of electricity can be reduced gradually.

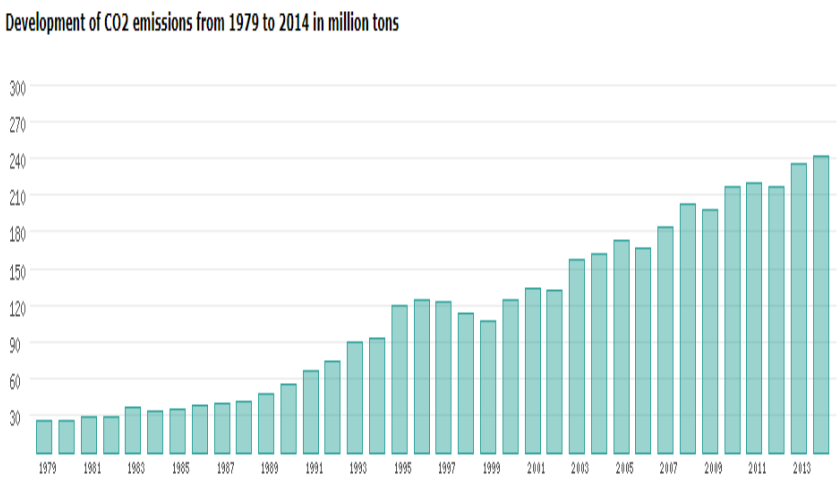

Figure 1.2: Development of CO2 emissions

Thermal energy is one of the main reasons of high electricity consumption. For industrial processes, thermal energy is required for maintaining temperature of products or processes. This process heat for low-to-medium or high temperatures which accounts for 33% of global industrial energy consumption(Wahed, Bieri, Kui, & Reindl, 2018). Domestic and commercial building such as hotels and condominium needs hot water for bathing purposes. Figure 1.3 shows the average energy end use for domestic and commercial. One of the best renewable energy that can be utilized is solar thermal energy for water heating. In 2014, about 140 solar thermal plants with a total capacity of 93 MW/th have been installed globally for industrial applications.

Recently, Malaysia has participated in United Nations Framework Convention on Climate Change (UNFCC)'s Conference of Parties-15 (COP15) in Copenhagen. This objective of COP15 is to reduce GHG emissions of 40% by 2020. Demand side management (DSM) can be an additional important mechanism to pointedly use flexibility of the energy demand. Consequently, the transition of the energy market is linked to the technological developments as well as to reassignment of roles to the actors in the market.

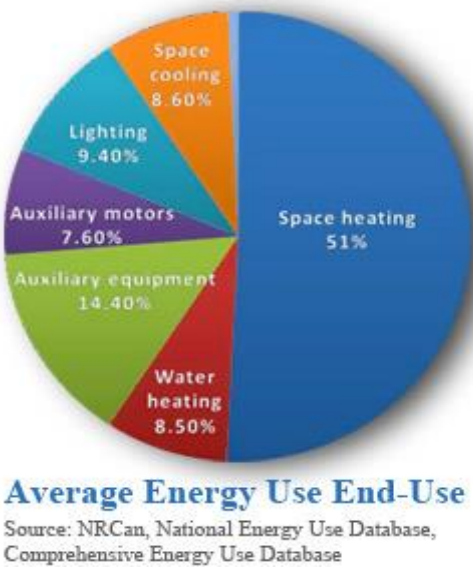

Figure 1.3: Average Energy Use End-Use

In this research study, it is mainly focused on DSM of buildings for water heating and the impact of solar thermal technology application in the same building.

1.2 Problem Statement

Electrical water heating system is the most common practice in Malaysia. Hotel facilities are a very specific group of buildings when it comes to demand for power, hot water preparation and heating. Heating and hot water preparation are one of the largest operating costs of total energy consumption. The energy demand for electricity production is relatively high. More and more power plants are commissioned in Malaysia to suffice the energy demand. Conventional fuels, such as coal, natural gas, and fossil fuel, are constantly being depleted however, the world's dependency on these fuels is still growing. For these reasons, Malaysia and the world are pursuing alternative fuel sources to lessen the dependency on non-renewable fuels.

Hence, solar thermal technology being widely explored in the last decade for a clean energy. Solar thermal is an alternative because it is renewable, cost saving and low maintenance required for the commercial practice. In addition, energy consumption should be properly managed and give more priority on the energy management system. Therefore, energy demand of Hotel Temasek, Melaka need modifications. This study emphasizes on usage of solar thermal replacing conventional heater which uses electricity.

1.3 Objectives of the Study

In this study, the objectives were as follows:

I. To identify the integration point for application of solar thermal technology to maintain the temperature of the storage tank

II. To determine the most suitable collector and its field size considering load, global radiation and thermal storage volume.

III. To analyse the effect on energy saving and economic analysis for before and after solar thermal technology installation scenario

1.4 Scope of the Study

This research study covers the potential energy saving for Hotel Temasek, Melaka. The main heating requirement for the building are the guest rooms Identified potential DSM will be mapped and analysed using Sankey diagram. Moreover, the integration of a solar thermal system into the industrial process where the temperature ranges of the commercial demand are available which are 60-70℃. To ease the heat integration process, a software provided by UNIDO Malaysia, Solar Heat for Industrial Processes (SHIP) Design tool will be utilized. Historical data will be analysed to find out the solar

irradiation. Economic analysis will be conducted for current consumption of the building and after solar thermal installation to the building.

1.5 Significance of the Study

In energy or electricity management, ability to optimize results in a constrained environment is a key to success for load management. Thus, this study has been proposed to analyse and determine the most suitable measures to accommodate needed energy for the hotel. Also, the study signifies the benefits and advantages of solar thermal technology to replace or reduce the current practice on non-renewable fuel combustion. This can contribute to facilitate more solar thermal projects for other industries as well. For the cost-competitiveness of solar thermal systems, it will be essential to compare the investment with the long-term fossil fuel price trends of the industry. Through this study, data will be obtained and analysed for real industry application for further improvement in future research studies.

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