ENERGY EFFICIENT RESIDENTIAL BUILDINGS ASSESSMENT USING BUILDING INFORMATION MODELING

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Dedicated specially

To my beloved Father and Mother

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ABSTRACT

Energy efficiency is using less energy to provide the same level of performance, comfort, and convenience. Energy Efficient Home is a building that utilizes minimum energy needed to heat and cool the interior of a building with the added feature of making this space healthy and comfortable for human occupation, which includes air quality, moisture conditions, and lighting. The ideal energy efficient home maintains the best environment for living while reducing the cost of energy. These buildings have a number of advantages such as improved comfort, reliability, energy security, and environmental sustainability, which are the consequences of independency of fossil fuel consumption and less release of CO2 emissions. This thesis analyzes a Low Energy underground cooling ventilation to providing thermal comfort in Malaysia. In the analysis of the case study several factors are considered, including: orientation, window location and size, glazing type, wall and roof insulation levels and efficiencies of cooling systems. First, the case study was modeled based on the current situation and data gathered and cooling load calculated. Next, the optimal design features determined for selected case study in Malaysia. The optimization results indicate that changing orientation and materials such as windows and walls are required energy efficiency measures to design high energy performance homes throughout climatic zones in Malaysia. In particular, it was shown that implementing these measures can cost-effectively reduce the annual energy use by 32% compared to the current design practices of home in Melaka.

ABSTRAK

Kecekapan tenaga menggunakan tenaga yang kurang untuk menyediakan prestasi, keselesaan, kemudahan pada tahap yang sama dan. Rumah Cekap Tenaga adalah bangunan yang menggunakan tenaga minimum yang diperlukan untuk memanaskan dan menyejukkan bahagian dalaman bangunan dengan ciri-ciri tambahan yang menjadikan ruang ini lebih sihat dan selesa untuk diduduki, termasuk kualiti udara, keadaan kelembapan, dan pencahayaan. Rumah cekap tenaga yang ideal mengekalkan persekitaran terbaik untuk diduduki di samping mengurangkan kos tenaga. Bangunan-bangunan ini mempunyai beberapa kelebihan seperti memberi keselesaan yang lebih baik, kebolehpercayaan, keselamatan tenaga, dan kemampanan alam sekitar, yang merupakan akibat daripada penggunaan bahan api fosil dan kurang membebaskan CO2. Tesis ini menganalisis penyejukan Tenaga pengudaraan Rendah bawah tanah untuk memberikan keselesaan termal di Malaysia. Dalam analisis kajian kes, beberapa faktor telah dipertimbangkan, termasuk: orientasi, tingkap lokasi dan saiz; jenis kaca, dinding dan tahap penebat bumbung dan kecekapan sistem penyejukan. Pertama, kajian kes telah dimodelkan berdasarkan keadaan semasa dimana data telah dikumpul dan beban penyejukan dikira. Seterusnya, ciri-ciri reka bentuk yang optimum ditentukan untuk kajian kes terpilih di Malaysia. Keputusan pengoptimuman menunjukkan bahawa perubahan orientasi dan bahan-bahan seperti tingkap dan dinding memerlukan langkah-langkah kecekapan tenaga untuk reka bentuk rumah prestasi tenaga yang tinggi di seluruh Malaysia. Secara khususnya, ia telah menunjukkan bahawa dengan melaksanakan langkah-langkah ini boleh mengurangkan kos serta penggunaan tenaga tahunan sebanyak 32% berbanding dengan amalan reka bentuk rumah yang sedang diaplikasikan di Melaka.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

During the past two decades, energy consumption growth has closely paralleled with population growth and it leads to continuous increase in energy prices and additional release of CO_2 and greenhouse gas emissions particularly in the building sector (Biaou, Bernier, Yan, 2006). In addition to this growing demand for energy, consumers are demanding increasingly flexible, convenient, and clean energy forms. The focus of a sustainable energy future has been towards the energy demand sector. The building sector particularly consumes around 40% of total consumed energy (Deng et al., 2011). As a result, reduced consumption in this sector has the potential for high impact.

Energy efficiency is using less energy to provide the same level of performance, comfort, and convenience. In building section, it is defined as the minimum utilization of energy needed to heat and cool the interior of a building with the added feature of making this space healthy and comfortable for human occupation. Therefore, it is a building that uses less energy and is more comfortable and healthier than before. This includes air quality, moisture conditions, and lighting. The ideal energy-efficient home retains the best environment for living while minimizing the cost of energy. (Dennis Crook, 2006)

Energy efficient buildings provide a technically practicable method to reducing energy consumption in buildings. It is designed to deliver maximum comfort to occupants by making the most of free natural heating, cooling and lighting and utilizing efficient design principles and building materials to reduce the need for appliances and its design principles is becoming more practical to adopt due to the increasing costs of traditional fossil fuels and their negative impact on the planet's climate and ecological balance. An energy efficient home costs no more to build than a conventional home, but is more comfortable and easier to maintain and has reduced unnecessary energy consumption, greenhouse gas emissions and demands for non-renewable resources. They simultaneously provide healthier living conditions and offer homeowners significant money savings over conventional homes. Many factors can comprise residential energy efficiency, and both new and existing homes can be improved with energy efficient strategies and products.

In energy efficient homes, efficiency boosting technology reduces the building loads. With the lower energy demand, solar and other renewable technologies have the potential to meet most of a buildings energy needs. Energy efficient homes include the following design features:

- Climate-specific design
- Energy-efficient constructions and building products/materials
- Energy-efficient appliances and lighting
- Renewable energy technologies

The energy efficient home design principle is becoming more practical to adopt due to the increasing costs of traditional fossil fuels and their negative impact on the planet's climate and ecological balance. These buildings have a number of advantages:

- Improved comfort: An energy-efficient building envelope reduces temperature fluctuations
- Reliability: It can be designed to continue functioning even during blackouts

- Energy security: A building that produces energy protects its owner from fluctuations in energy prices
- Environmental sustainability: It saves energy and reduces pollution

1.2 Background of Study

Construction of energy efficient homes is an important lever for reducing energy consumption. By increasing cost of energy between years 1970 to 1980 in most of the world, engineers thought about constricting buildings with low energy consumption (Safa, Rahimi, 2012). The first symptom of interest to decrease the energy consumption dates back to before World War II and it began with research on solar heating system in Massachusetts Institute of Technology (MIT). (U.S. department of energy, 2003)

In the quest for a sustainable energy future, focus has been shifting towards the energy demand sector. One of the key demand contributors is energy use in buildings. The extended lifetime of buildings, ranging from 50 to 100 years, has a large impact on energy use patterns. Therefore, it is difficult to change building energy use patterns quickly. One method for minimizing building energy use is through the promotion of energy efficient buildings. (Kadam, 2001). An energy efficient building has the below strategies:

- Reduces domestic electricity consumption through energy efficient appliances and lighting;
- Reduces household water heating requirements through water efficient appliances;
- Reduces space heating and cooling energy using an energy efficient building envelope; and
- Uses appropriate site-based renewable energy systems to supply heat and electricity.

To construct such buildings and to reach the goals, on one hand, energy consumption of buildings should decrease; on the other hand, generation of renewable energies should be substituted with fossil energy consumption. Today, by decreasing the supply of fossil fuels, rising cost of energy and emerge of new technologies, it is a necessity to move from conventional buildings toward energy efficient buildings. In addition, because of the decreasing costs of solar systems of about 80% during two past decades, tendency to use these systems increased. According to statistics announced, in energy efficient buildings, consumption of energy compare to conventional buildings is so much lower and this amount in US is 75%, in UK 77% and in Ireland is 85%. (Safa, Rahimi, 2012)

The parameters that influence energy use in buildings are as follows: site analysis, home orientation, room configuration, building envelope, space planning, ventilation, insulation, heating, cooling, lighting and appliances, water heating, and waste management. The most important factors that have the most influence are orientation, ventilation, insulation and weather condition.

1.3 Problem Statement

Even though there are several studies that have been undertaken towards energy efficient buildings all around the world only few concepts are available for residential energy efficient buildings in Malaysia. More attention and research needs to be conducted to promote the usage of renewable energies in housing industry and come up with appropriate designed concepts for energy efficient homes based on conditions in Malaysia.

Energy is essential to our daily lives. It heats our homes, fuels our transport and supplies our electricity. At the moment, most of the energy we use comes from fossil fuels such as oil, gas, coal and peat. Unfortunately there is a limited supply of fossil fuels in the world and we are using them up at a very fast rate. In addition, developing energy efficient homes can reduce independency to fossil fuels and release of CO_2 emissions in countries similar to Malaysia that do not have a vast source of energy. Additionally, Malaysia is located near the equator which has enough sunny days and is capable of generating huge amounts of clean energy. Unfortunately, this advantage of region do not utilized proper and these capacities ignored somehow.

The other problem that constructing energy efficient homes face with is that very few architects and constructors have the necessary skills or experience to build them and it should be rectified by conducting more research and training more designers and engineers. Also, with government support, these projects can move forward towards the construction of energy efficient homes.

1.4 Aims and Objectives

Successfully meeting the goals, which is using less energy to provide the same level of performance, comfort, and convenience is the ultimate destination for energy efficient buildings. The main aim of the study is to analyze a successful energy efficient home (CoolTek Home) in the weather conditions of Malaysia in order to come up with the optimal principles for energy efficient homes in the country. The objectives of this study are as following:

- To identify and gather required data and information about CoolTek Home.
- To simulate CoolTek Home by using suitable software.
- To analyze the energy consumption of CoolTek Home.

1.5 Scope of the Study

The scope of this study is focused on the following:

- Case Study: The CoolTek Home is located in Tiara Melaka Golf & Country Club, Ayer Keroh. It has a typical site plan with area about 200 m2, constructed by energy efficiency materials and using PV panels to generate a portion of energy required and also utilizing underground cooling ventilation to decrease the cooling load.

- Software: Revit and Ecotect are popular softwares for simulating buildings and analyzing energy from different aspects.

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