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Design a Zero Energy House in Brisbane, Australia

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Abstract

Due to the increasing energy demand and global warming effects, energy efficient buildings have become increasingly important in the modern construction industry. This research is conducted to evaluate the energy performance, financial feasibility and potential energy savings of zero energy houses. Through the use of building computer simulation technique, a 5 stars energy rated house was modelled and validated by comparing the energy performance of a base case scenario to a typical house in Brisbane. By integrating energy reduction strategies and utilizing onsite renewable energy such as solar energy, zero energy performance is achieved. It is found that approximately 66 % energy savings can be achieved in the household annual energy usage by focusing on maximizing the thermal performance of building envelope, minimizing the energy requirements and incorporating solar energy technologies.

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Keywords: Zero energy house; Subtropical climate; Financial feasibility; Building simulation

1. Introduction

Green building has attracted significant attention recently due to the rapid increase in energy consumption around the world, exhaustion of energy resources and environmental concern such as global warming. The global energy consumption is expected to increase by 56% between 2010 and 2040 [1]. Building energy load is one of the major contributions to the increasing energy consumptions and global warming. Researches have shown that the global

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energy consumption by the residential sector accounts for approximately 18 % of the total energy usage and is expected to increase by 1.5 % annually [2].

To address this issue, the Australian Sustainable Built Environment Council's (ASBEC) Zero Emissions Residential Task Group has appointed a team led by the Residential Development Council (RDC) to work on the target of achieving zero energy performance and zero carbon for new and existing homes by 2020. In addition, the Building Code of Australia has introduced several important changes in 2010, requiring all new homes to achieve a minimum of 6 star energy rating under the Nationwide House Energy Rating Scheme [3].

Zero energy house are typically houses with net zero energy consumption on a yearly basis, which means that the annual energy consumption is equal to the amount of renewable energy produced on site. The design of a zero energy house is basically reducing the energy consumed and meeting the demand on an annual basis by a renewable energy supply [4]. In the event where no renewable energy is available, electricity will be supplied to the house by the power grid. Power will be exported back to the grid when there is excess power generated by the renewable energy supply [5].

Although zero energy house can be built by the currently available technologies, the cost and repayment time often make it unattractive to many customers. This research project will focus on designing an affordable zero energy house based on a typical house in Brisbane, Queensland. Through the computer simulation, the energy performance of the house is investigated under Brisbane climate conditions. It is believed that the results obtained from the simulation will provide useful information on the possible energy savings of the different techniques. In addition, the result can also provide a guideline for the building industry. If the concept of zero energy house can be implemented throughout the whole Queensland, not only the energy consumption and greenhouse gas emissions will drastically decrease, but the annual household energy cost of Queensland residents will also reduce significantly.

2. Methods

This research was performed by using a building simulation software, which was used to simulate the building's performance based on the building model and climatic input data. Included in this section are the weather data for study location, building simulation tool, base case modelling and base case validation. The analysis of the energy reduction methods and the implication of solar energy will be discussed in the next section along with the results of the analysis.

2.1. Site location and weather data

Brisbane is the state capital of the Queensland, Australia. Its latitude is 27°23'S, the longitude is 153°07'E and the elevation is 4m. Brisbane has a humid subtropical climate with hot, humid summers and dry, mild winters. The summer (December – February) average temperature is 20-28°C, while the winter (June – August) average temperature is 11-21°C [6]. As the case study is located in Brisbane, the climate conditions of this research will be based on the Typical Meteorological Year weather profile dataset for Brisbane that can be downloaded from the U.S. Department of Energy website.

2.2. Building simulation tool

The EnergyPlus 8.1 building simulation software was applied to simulate the house energy performance in this paper. EnergyPlus is a building performance simulation program developed by U.S. Department of Energy. It integrates the existing features of BLAST and DOE-2 along with some additional new features [7].

EnergyPlus can model heating, cooling, lighting, ventilation and other energy flows. Some of the key capabilities include the ability to simulate time-step less than an hour, modular systems, heat balance-based zone simulation, daylighting control, thermal comfort and photovoltaic systems [8]. Therefore, EnergyPlus is an ideal software to model the energy performance of the zero energy house.