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The effect of building construction and human factors in cooling energy use

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Abstract

This study's purpose is to evaluate air-conditioning energy consumption by conducting interviews and recording data from 50 single-family houses. All study houses applying similar styles of tropical architecture and has similar methods of building construction, with the U-values for building materials having moderate levels of thermal resistance. The finding reveals that the majority of households spends more than 37% of their energy costs on cooling during the raining season and estimating to increase by the drought seasons. The greater use of air-conditioners has resulted in an increased purchasing power of the population.

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Keywords: Building constructions; energy costs; occupants; temperature

1. Introduction

Energy costs and environmental concerns have made it more important than ever to find ways to reduce energy consumption. As human consumption of energy continues to increase, it is important to improve the energy efficiency of our built environment. This will greatly benefit the environment, and the owners and users of buildings. There are many ways to improve the energy efficiency of the built environment. Envelope technologies, such as wall, floor, and roof insulation, high-performance windows and doors, and air infiltration, have a priority role in producing a comfortable interior. However, buildings in hot and humid climates still frequently depend on energy use to power cooling and ventilation systems to control the environment. The amount of energy used is

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dependent on some variables, such as climate, a building's orientation, and the structure and materials used in the construction of the building envelope. Of these, climatic factors have the most significant effect on the balance of energy use in buildings. Climate parameters, the influence of the building envelope and thermal comfort are factors that are closely related to the thermal performance of a house, and can combine to contribute to energy saving. These factors also significantly influence thermal performance and energy use. This study will evaluate the cooling energy use in hot and humid tropical environment by conducting interviews and recording data of building construction, and human factors from 50 single-family houses.

2. Literature review

The four physical climate parameters are air temperature, mean radiant temperature, air velocity, and humidity (Alread & Leslie, 2007; Fanger, 1973; Lechner, 2000; Moffat & Schiler, 1981). According to Givoni's (1969), the comfort zone is supposed to be between 20 and 27°C in temperature, and relative humidity (RH) between 20 and 80%. The air velocity indoors that normally occur in a small room is about 0–0.5m/s. Due to the differences between day and night temperatures, it is important to raise the comfort level at night. Physical strength and mental activity of all people are improved within a comfort zone (Furuta, 1978).

The building envelope is the interface between the exterior of the building and the interior environment. It includes the walls, roof, glazing and floor foundation. One of the most important factors affecting building envelope design is the climate (Misni, 2013). The material use of building envelopes conducts heat at different rates. The different components of the envelope, such as foundation, walls, beams, connectors and roofing materials, can create paths for the transfer of thermal energy, which conduct heat in or out of the envelope (Hartweg, 2007). The core purpose of the building envelope is to improve the comfort level for occupants when compared to the conditions in the exterior environment by protecting them from moisture, temperature and weather elements (Alread & Leslie, 2007).

A building's shape, solar orientation, interior layout and size are factors that affect its energy use and the requirements of the building envelope. The configuration of the house should be designed to suit the particular climate, it is located in to ensure the comfort of its occupants and for energy efficiency (Nervegna, 2003). Openings include windows, doors, and vents. Commonly, window openings must, by law, have a combined area of not less than one-tenth of the floor area of each room (UBBL, 2006). Krigger and Dorsi (2004) stated that window glass transmits between 20–84% of the sun's heat, depending on types of glass. Shading window glass affects the quantity of radiation that enters a room, and hence modifies the heat flow to the interior (Givoni, 1969). To get the best effect, windows must be shaded from direct solar radiation (Lechner, 2000). Positioning a long solid wall to the east-west position minimises the amount of daylight that enters the internal space, which reduces cooling effects.

The use of light coloured surfaces of buildings and outdoor urban areas is practiced in areas which have a large amount of sunshine because they can reflect solar radiation and reduce the amount of heat absorbed by the building. Taha (1997) suggested that reasonable increases in urban albedo can achieve a decrease of up to 2°C in air temperature. Modifying the value of albedo for a building's envelope, particularly the walls and roof, can potentially reduce the ambient temperature in individual buildings and their surrounding environment, helping to keep entire neighbourhoods cool.

Electrical energy is an essential energy source that has been drastically increasing in cost. In Malaysia, demand for electrical energy is increasing each year, at an average rate of 11.2% per annum (Nasution & Hassan, 2009). The consumption of electricity includes the application of lighting, electrical appliances, machinery, and air conditioning systems. The role of air conditioning systems in the tropics is using the energy for cooling, due to its year-round hot-humid climate. There are two systems of air-condition in usually used for residential building; window and split (McDowall, 2007). Window air conditioners are one of the most popular and the cheapest of all air conditioning systems. Growth in the use of air conditioning has increased in residential buildings in Malaysia from 13,251 units in 1970 to 253,399 in 1991 (Mahlia, Masjuki, & Choudhury, 2002). This figure is predicted to reach about 1,511,276 units in the year 2020. Population growth, improved living standards and urban heat island effects in cities are the main factors that have contributed to the dramatic increase in air conditioner use in residential buildings in Malaysia. However, the source of energy continue to decrease; it is important to improve the energy efficiency of our built environment.