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Thermal Comfort in Zero Energy Buildings

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Abstract

This paper evaluates thermal comfort in domestic zero energy buildings. Dynamic simulations are used to assess a variation of scenarios including: construction types, natural ventilation strategies, solar shading, and occupancy periods in a low energy case study dwelling, within the United Kingdom. The Chartered Institution of Building Services Engineers Technical Memoranda 52 (CIBSE TM52) is used to evaluate the thermal comfort conditions, and the state of overheating within the case study dwelling. The results indicate that increasing the thermal mass of the external walls significantly reduces the risk of overheating within the case study dwelling. Additionally, the most beneficial window opening profile is night ventilation. The addition of solar shading on the South, East and West elevations considerably improved thermal comfort conditions. Increasing the effective openable glazing area to facilitate natural ventilation in zero energy buildings and further improve the indoor thermal comfort.

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Keywords: Overheating, Thermal Comfort, Zero Carbon, Zero Energy, Housing

1. Introduction

Sustainability has progressively become a pressing issue throughout the world, with many countries supporting policies to reduce carbon emissions. A large portion of domestic buildings are still dependant on fossil fuels as a source of energy [1], contributing to more than 30% of carbon emissions in the United Kingdom [2], therefore producing zero carbon homes would significantly decrease this. The UK has incorporated policies such as The Code for Sustainable Homes (CSFH) [3,4] to increase the energy performance of domestic dwellings, as well as assessment tools such as PassivHaus [5] and BREEAM [6] that are used to evaluate building design [1]. Furthermore, increasing the energy

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efficiency portrays increased air tightness, and therefore represents a negative impact on the indoor environment and health and wellbeing of occupants. Recently, the UK Government have withdrawn the CFSH [7]. Buildings have been idenfitied as providing the greatest opportunity to reduce carbon emissions [4]. Therefore, The Building Regulations, CIBSE Guide A [8] and additional policies are tightening the restrictions with the aim to provide increased efficiency and air tightness within domestic houses.

Studies have been conducted regarding methods to intergrate zero carbon in existing and new buildings [1,4,9] as well as assessing the carbon emission impact of buildings [10]. However, the negative impact on the indoor environment has not been fully assessed.

Yu and Kim [11] have previously conducted research in order to identify the health conditions related to indoor pollutants and poor indoor air quality. According to Yao and Yu [2], the correlation between the indoor environment and occupant satisfaction in low energy homes has not been previously researched. Therefore, it is unknown whether these types of dwellings are providing a satisfactory indoor environment for the user.

Ucci and Yu [12] have also voiced concerns related to the disregard of occupant health and wellbeing throughout energy related policies, due to the lack of evidence related to this topic. The NHBC Foundation [13] have stated concerns from both building occupants and builders with regards to the consequences related to increasing the air tightness within dwellings. Further to this, Ucci and Yu [12], Yu and Kim [11] and Howieson, Sharpe and Farren [14] have recommended the need for policies that evaluate the indoor environment and health and wellbeing of occupants prior to the construction stage. Yao and Yu [2] and Hashemi and Khatami [15] outline the need for additional research into whether low energy buildings are providing 'healthy indoor environments', this research will address the issue through assessing the collected simulation data.

To this end, the aim of this paper is to provide recommendations to improve thermal comfort conditions in low/zero energy homes. This study evaluates the conditions of a low energy case study building in order to assess alternative methods to reduce risk of overheating and thermal discomfort in zero energy buildings.

1.1. Zero Carbon Homes

Within previous years, increasingly airtight structures have been developed, along with the combination of improved thermal insulation, high performance windows, and additional U-value reductions throughout new buildings [16]. The requirement for lower carbon buildings and the development of knowledge and technologies resulted in the inclusion of policies to outline targets for the reduction of carbon emissions. Zero Carbon Hub [17] defines that a 'zero carbon home' must meet the following three criteria:

- The fabric performance must comply with the Fabric Energy Efficiency Standard (FEES).
- The total amount of carbon emissions ("after consideration of heating, cooling, fixed lighting and ventilation") must satisfy the Carbon Compliance limit, established for zero carbon homes.
- The fabric performance must comply with the Fabric Energy Efficiency Standard (FEES).

Once criteria one and two have been met, the remaining carbon emissions must be reduced to zero.

The Zero Carbon Hub [17] states that the zero carbon policy comprises of: fabric energy efficiency, on site low or zero carbon heat and power, as well as allowable solutions.

The UK Government proposed a 'Code for Sustainable Homes' policy in 2006, outlining the intention for new constructed dwellings to be zero carbon by 2016 [18]. The program to achieve zero this aim is shown in Table 1.

Table 1. Code Levels for Mandatory Minimum Standards in CO_2 Emissions [19]

Code Level	Minimum Percentage Improvement in Dwelling Emission Rate over Target Emission Rate
Level 1 (★)	0% (Compliance with Part L 2010 only is required)
Level 2 (★★)	0% (Compliance with Part L 2010 only is required)
Level 3 (★★★)	0% (Compliance with Part L 2010 only is required)
Level 4 (★★★★)	25%
Level 5 (★★★★★)	100%
Level 6 (★★★★★★)	Net Zero CO_2 Emissions