THE PERFORMANCE OF ECO-REFURBISHED HOUSING UNDER CURRENT AND FUTURE UK CLIMATES

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Summary

Concerns about climate change impacts led the UK government to commit to reducing CO_2 emissions to 80 % of 1990 levels by 2050. This will require major action in order to decrease energy consumption in buildings, especially housing. However, 70 % of all current homes in the UK will still exist in 2050. Therefore, the refurbishment housing to be low carbon is critical if CO_2 reduction goals are to be met. This study examines the benefits of sustainable refurbishment on building performance in terms of carbon emission reduction and also heating and cooling requirements for current and future climates. An eco-refurbished Victorian house in Liverpool, UK has been modelled and simulated (before and after refurbishment) using current and future weather data for Liverpool. Real world monitoring was also undertaken at the Liverpool house for validation of the computer predictions. Simulation results tended to suggest very little decline in heating demand in the future for the house with no refurbishment, whilst the eco-refurbished home showed a significant reduction in energy demands and CO_2 emissions in the future.

Keywords: climate change, low carbon housing refurbishment, Victorian house

1 Introduction

1.1 Climate change and the UK housing stock

There is strong evidence that the Earth‘s climate is changing. To tackle this the UK government has set challenging carbon reduction targets of achieving an 80 % cut in emissions by 2050. In 2009, the residential sector accounted for 27 % of final-user emissions according to the UK Department of Energy and Climate Change (DECC). Therefore, reducing energy demand in the existing residential building stock has been identified as a core aim of UK and EU energy policies to mitigate climate change and reduce global warming trends. Whilst the Code for Sustainable Home in the UK is requiring dwellings built from 2016 onwards to be net zero carbon, it is important to remember that the existing housing stock has an even bigger role to play in reducing carbon dioxide (CO_2) emissions. Current predictions estimate that in 2050 two-thirds of today's dwellings, many of which have low energy efficiency, will still be an active part of the UK's housing stock. As a result, eco-refurbishment of these poorly performing homes is critical if reduction targets are to be met. Essentially, a typical eco-refurbished house is air-tight and super-insulated, with mechanical ventilation and heat recovery (MVHR) and multi-glazed windows [1]. The overall aim of eco-refurbishment is to find methods by which the UK government's commitment to an 80 % reduction in CO_2 emissions by 2050 (compared to 1990 levels) might be met within the existing housing stock.

1.2 The Research Objectives

This paper addresses the benefits of the eco-refurbishment of very old housing in terms of carbon emission reductions and heating consumption for current and future climates. Virtually all old housing is hard to heat and expensive to treat and, therefore, not many have been subject to major refurbishment [2]. Research of such buildings can examine the challenges and opportunities of eco-retrofitting whilst attempting to maintain the aesthetic of the original property. Also, changes in climate will impact on the energy performance and demands of the built environment. Recognising this, it is important to consider how to apply the knowledge and technologies of eco-refurbishment in the context of future climates.

2 Case study

In March 2009 the UK's Technology Strategy Board (TSB) launched a competition, *Retrofit for the Future*, to encourage construction companies to retrofit and refurbish existing housing to make deep cuts in carbon emissions. The competition's standards (per m^2 of floor area) were: maxium CO_2 emissions of 17 kg/m^2/yr and maximum primary energy use of 115 kWh/m^2/y [3]. 87 schemes were approved, including one in Liverpool at 2 Broxton Street, Wavertree, Liverpool, which was chosen for this case study. Figure 1 shows the refurbished property which, externally, looks virtually identical to the original dwelling. This 19th century end-terraced house was refurbished by the Plus Dane Group. The retrofit of the building included: very high levels of insulation, timber framed triple glazed windows, very high levels of airtightness @50Pa (air permeability of 2.75m^3/hr/m^2 @50Pa), mechanical ventilation with heat recovery, solar gain via a new conservatory, LED lighting in the kitchen and bathroom, and A-rated low energy appliances [4].

Fig. 1 *Terraced house after refurbishment*

3 Methodology

3.1 Modelling

The 19th century end-terraced house was modelled (before and after refurbishment) using the advanced thermal simulation package DesignBuilder. Table 1 compares the pre and post refurbishment thermal features of the house. In addition, the energy and CO_2 performances of the pre and post refurbished dwelling were examined for current and future climates of Liverpool to evaluate the effect of eco-refurbishment on energy consumption and CO_2 emissions both now and in the coming decades.

Tab. 1 *Pre and post refurbishment thermal features of a 19th century terraced house*

Element	Roof	Walls	Floor	Windows	Doors
Typical existing construction (Fabric U-value, W/m^2K)	0.40	2.10	0.50	4.80	3.00
Upgraded fabric construction (Fabric U-value, W/m^2K)	0.15	0.11	0.12	0.78	1.00

3.2 Weather Data for Simulation

The PROMETHEUS project [5] recently produced a number of EPW future weather files using the UKCP09 weather generator, which can be used to 'future-proof' buildings against predicted climate change. It also represents a random sampling of a probability distribution function and hence the probabilities of a particular level of climate change. In this paper the results from current and 2050 high emission scenarios at the 50% probability level for Liverpool will be presented.

Tab. 2 *2009 and predicted 2050 external air temperature in °C for Liverpool, UK*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	4.1	4.2	5.7	8.2	11.6	14.2	15.9	15.9	13.6	10.6	6.5	5.0
2050	6.2	6.4	8.0	10.1	13.7	17.0	18.6	18.5	16.4	13.4	9.9	7.4

4 Results and discussion

The pre and post-refurbished house under current and future weather condition was simulated to see if the UK's 80% carbon reduction target was achievable by refurbishment. Simulation results given in Figure 2 show the annual heating demand for the pre and post-refurbished houses in Liverpool for different scenarios. Significant heating demand reductions can be seen after refurbishment. Figure 2 also confirms that, despite the fact that heating energy consumptions are affected by climate change, there is very little decline in future heating demand for the house with no refurbishment, whilst the eco-refurbished dwelling shows a sharp reduction of more than 70 % in energy demand. Figure 3 shows changes in CO_2 emissions for the pre and post-refurbished house under current and future weather data for Liverpool. It can be seen that there is a large reduction of around 83 % for the house following refurbishment. Future CO_2 emissions show a slight downward trend for the house with no refurbishment, and the eco-refurbished dwelling shows a very small reduction in CO_2 emissions due to its existing current heating demand already being low.

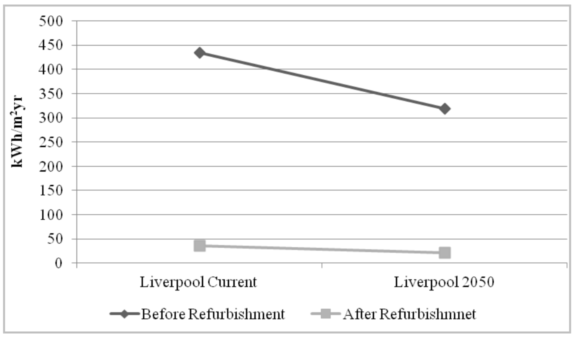

Fig. 2 *Annual heating demand (kWh/m^{2}yr) for the pre and post-refurbished terraced house under current and future weather data of Liverpool*

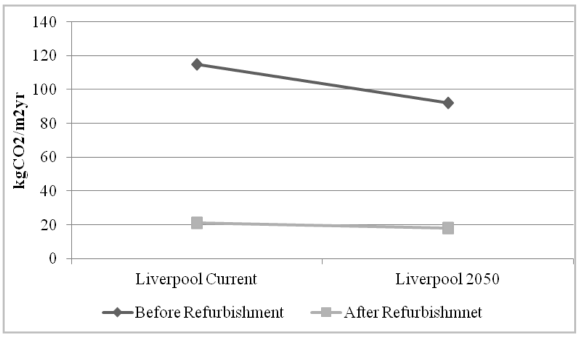

Fig. 3 *Annual CO_2 emissions (kgCO_2/m^{2}yr) for the pre and post-refurbished house under current and future weather conditions in Liverpool*

5 Conclusions

Results indicate that energy demands and CO_2 emissions experience a sharp decline following eco-refurbishment. It is also important to check if eco-refurbishment strategies will continue to provide comfortable environments under future weather conditions in the UK. Results show it does in terms of providing healthier and warmer condition by reducing carbon emission and heating demands.

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