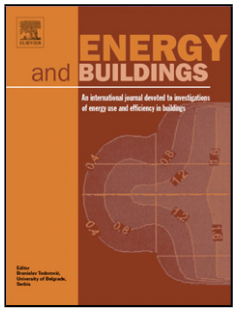

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EVALUATION OF LIFE CYCLE CARBON IMPACTS FOR HIGHER EDUCATION BUILDING REDEVELOPMENT: A MULTIPLE CASE STUDY APPROACH

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ABSTRACT

UK higher education institutions have strong drivers to reduce operational carbon emissions through building redevelopment. The life cycle carbon impact of buildings - operational and embodied carbon - is a developing area of consideration, particularly in redevelopment. A case study analysis was employed to assess how redevelopment interventions can reduce life cycle carbon impacts.

The five case study buildings covered a variety of activities, construction styles, systems and operational characteristics. Each building was monitored over a 12-month period and the data was combined with metered energy use to calibrate life cycle carbon base models following the BS EN 15978:2011 standard. The base models were modified to simulate a range of carbon reduction interventions and also new-build to current UK energy efficiency regulations. The design stage uncertainty was factored in.

The best-case refurbishment options showed average life cycle carbon savings of between 20 and 29%, with the most effective intervention varying by building. For new-build, the savings ranged from 32% of 64%, with the greatest being for conversion from mechanical to natural ventilation. The average contribution of embodied carbon to total life cycle carbon impact for the new-builds varied from 6% for the chemistry building to 23% for the law building.

Keywords: higher education; university; life cycle carbon; embodied carbon; retrofit; uncertainty

1. INTRODUCTION

The UK higher education sector comprises over 150 higher education institutions (HEIs) and accommodates 2.5m students [1]. In total the sector contributes to approximately 0.5% of the UK's total emissions [2], with carbon emissions having risen by 33% from 1990 to 2005. In line with UK policy, there is a sector target to counter this expansion and to reduce emissions by 43% by 2020 and 83% by 2050 against a 2005 baseline [3].

The higher education sector has a number of distinct challenges with regards to carbon emissions: large proportions of estate area used for energy intensive scientific teaching and research [4]; irregular occupancy patterns owing to teaching and research demands [5]; transient populations requiring repeat behavioural reinforcement [3]; ageing estates with many buildings deteriorating and pre-dating modern energy efficiency standards [6]. Individual HEIs also have strong drivers to manage their carbon emissions, including utility cost and energy levy savings, building energy-related schemes and legislation such as Part L of the Building Regulations, participation in the EU