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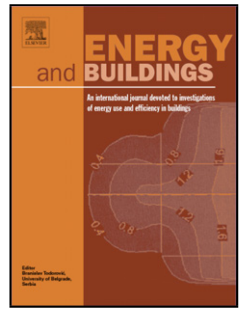

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Measuring and accounting for solar gains in steady state whole building heat loss measurements

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Abstract

To ensure good thermal performance is delivered consistently and at scale, there is a need to measure and understand the as-built heat loss of dwellings. Co-heating is a steady state, linear regression method, used to measure whole building heat transfer coefficients. This paper assesses the uncertainties in such outdoor, in situ, measurements due to the presence and treatment of solar gains. Uncertainties relating to solar gains are explored through both a number of field test results and simulated co-heating tests. Results demonstrate the potential for fractions of solar gains received on one day to be re-emitted on subsequent days. This dynamic behaviour can lead the steady state analysis to underestimate heat loss. Furthermore, inappropriate measurements of on-site solar radiation are shown to lead to bias in heat loss measurements. In particular, horizontal on-site solar radiation measurements are shown to significantly overestimate heat loss in buildings experiencing high proportions of direct gains through vertical openings. Both forms of uncertainty are dependent upon both the environmental test conditions and the characteristics of a test dwelling. Highly glazed, low heat loss and heavyweight buildings prove to be the most susceptible to such uncertainties, which ultimately limit both when tests can be successfully performed and which buildings can be tested.

Keywords:
Outdoor testing, co-heating, heat loss coefficient, whole house heat loss, in-situ measurements, thermal performance, performance gap, uncertainty, solar gains.

1. Introduction

Addressing the performance gap, the difference between predicted and measured performance, has emerged as a key issue in reducing the energy demand and carbon emissions associated with the built environment [1, 2]. Studies that have specifically examined the thermal performance of the building fabric have provided evidence of a trend for higher than predicted measured heat loss among new builds [3, 4, 5, 6, 7] and of heat transfer mechanisms existing that significantly alter the performance of components and building envelopes [8, 9, 10]. Equally, the long assumed performance of traditional constructions have been called into question by recent field measurements, with lower than predicted U-values measured in both traditional stone and brick walls [11, 12, 13, 14].

Evidence suggests that this gap emerges through processes operating across all stages of the design and build process [15]. To reduce the risk of a gap in delivered performance undermining energy and carbon reduction policies, these processes need to be identified and understood to ensure good thermal performance is achieved in practice, on a consistent basis and at scale. Co-heating tests can provide measurements of the heat loss or transfer coefficient (HTC) of a dwelling [16], capturing the heat loss across the entire building envelope and as a result of multiple heat transfer mechanisms and interacting components. As such, the top-down, whole building heat loss measurement achieved by co-heating tests holds some alternatives to, and advantages over, discrete measurements of single heat loss mechanisms (e.g. infiltration measurements [17]) or spot measurements (e.g. in situ U-value measurements [18]).

An understanding of heat loss reflecting the full build process is likely to require some degree of in-situ measurement of the thermal performance of conventional buildings in the field, and therefore within the outdoor environment. This inevitably reduces the degree of experimental control and presents a number of measurement challenges. In particular, this applies to the handling of solar radiation and the incorporation of solar gains into energy balance models. It is the uncertainty introduced by the presence of solar radiation in steady state co-heating measurements that this paper aims to address through three key aims:

- Identify the uncertainty within co-heating heat loss measurements associated with the presence of solar radiation.
- Characterise the resulting uncertainty and how it impacts heat loss measurements.
- Determine how these uncertainties can be addressed within the confines of the steady state method.

Before these aims are addressed, the co-heating methodology and its handling of solar gains is briefly reviewed.

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