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The challenges of monitoring energy consumption to assess behavioural changes in occupants during renovation projects from a low budget point of view

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Abstract

This study presents the challenges of monitoring energy consumption to assess behavioral changes in occupants during renovation projects and how to develop a strategy to overcome those challenges. Three buildings containing seventeen flats in total were monitored during a period of over two years, monitoring energy consumption and internal temperature of the flats. The energy consumption for the flats was capture by the use of a Current Cost smart meter placed at the ground floor of each block of flats in a cover under stairs. Wireless sensors were clamped to each flat. The smart meters were not connected to the internet or a computer, but instead the data was stored in the internal memory of the equipment and manually downloaded to a computer at each data collection visit. For the purpose of double checking, meter readings were collected at the electricity meter to be able to compared the accuracy and success of the data collected by the Current Cost smart meters. The internal temperature of every flat was collected by mean of a LogTag temperature data. From comparing the Current Cost smart meter data versus the utility meter readings a huge range of overestimation and underestimation of the actual energy consumption was observed. Regarding the internal temperature monitoring, long periods of lost data was identified. The main factors contributing to these data lost were: Long periods between data collection, wireless signal drop offs, unplugging, tampering and removal of equipment. A normalized energy index, based on utility meter readings, internal temperature and outdoor conditions, was developed to overcome the loss of data and assess the effectiveness of the technology and the behavioral change in the occupants. The normalised energy index provides a methodology to evaluate technology and behavioural changes effect between flats and across seasons.

Peer-review under responsibility of the organizing committee of the SBE16 Tallinn and Helsinki Conference.

Keywords: Monitoring; Renovation; Energy

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1. Introduction

The United Kingdom has agreed to a CO_2 emission reduction of 80% from 1990 levels by 2050 [1], while its housing stock is one of the eldest in Europe with 55% of dwellings dating from before 1960 [2]. To achieve this target, energy efficiency, low carbon technologies and behavioural changes projects are being deployed across the country and furthermore, all over Europe. Projects involved in reducing green house gases must be monitored to assess the impact, if any, of the implementations [3].

This study presents the challenges of monitoring energy consumption to assess behavioral changes in occupants during renovation projects and how to develop a strategy to overcome those challenges.

Air source heat pump has been found to reduce energy bills for domestic heating in the UK [4]. Air source heat pumps were used to retrofit two buildings, while a third building was continuing using electric storage heaters. Each building was fitting with a communal heat pump, serving space heating to eight flats in each building. Domestic hot water (DHW) was supply by electric immersion heaters on each flat.

The three buildings containing seventeen flats in total were monitoring during a period of over two years, monitoring energy consumption and internal temperature of the flats to provide quantitative data for the evaluation of behavioural changes on the tenants.

The aim of the project was to understand the effect of renovating the heating system, from electrical storage heaters to an air source heat pump with wet radiators, and behavioural changes in the occupants using the new technology.

The author's involvement in the project, relates to the data analysis, interpretation and liaison with the behavioural changes assessment, while the data collection described in this paper was carried out by a third party company.

2. Research Methods

Energy consumption and internal temperature was decided to be the quantitative data required to be able to quantify energy reduction for each flat but as well to assess the behavioral changes of the tenants following a series of intervention, which lay outside the scope of this paper.

The buildings and flats were far from being categorised as ideal candidates for a project of these characteristics. Insulation and airtightness levels were not optimal for the installation of air source heat pump to supply space heating to these flats.

While different energy monitoring solutions are available in the market with capabilities to capture a range of data at very small intervals, the monitoring strategy for this project was to have a low budget approach to expenditure but expecting to provide monitoring data at small intervals.

The approach taken to monitor energy consumption and internal temperature will be presented in the next two sections. Although some commonalities are share between the two monitoring approaches, the individual issues will be clearer presented having its own section

2.1. Energy Consumption

The energy consumption for the flats was captured by the use of a Current Cost EnviR smart meter [5] placed at the ground floor of each block of flats inside a cover under the stairs. Figure 1 shows the Current Cost EnviR smart meter, which according to a review on smart metering technology [6], belongs to group 1 providing real time energy consumption and a rough estimate of costing. Group 1 is the first step access level into smart metering, having a lower cost than groups 2 and 3 and very desirable in low budget projects. Wireless sensors were clamped to each flat's electricity meters. The Current Cost smart meters were not connected to the Internet or a computer, but instead the data was stored in the internal memory of the equipment and manually downloaded to a computer at each data collection visit to the buildings. Energy consumption was recorded at 24 hours intervals.

For the initial purpose of double checking, utility meter readings were collected for each electricity meter to be able to compared the accuracy and success of the data collected by the Current Cost EnviR smart meters, as utility meters provide the most accurate measure of actual energy consumption [7].