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Evaluation of the space heating calculations within the Irish Dwelling Energy Assessment Procedure using sensor measurements from residential homes

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Abstract

The monitoring phase of the SERVE project (March 2011 to July 2013) collated hourly and sub-hourly measurements of room temperatures and separate space heating durations over *two* full heating seasons, in up to 67 retrofitted dwellings in Ireland. Individual heating patterns and actual heated-period room temperatures are identified and compared to Ireland's Building Energy Rating (BER) model, the Dwelling Energy Assessment Procedure (DEAP), concluding that, following technical upgrades, DEAP over-estimated heating schedules and room temperatures by up to 37% and 1°C respectively.

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Keywords: Energy performance gap; retrofitted homes; internal temperatures; heating hours; DEAP model.

1. Introduction

Forecasting the energy savings potential from the housing sector has been hindered by a lack of understanding as to why building physics (asset) models of household energy consumption do not match the actual energy consumed in households. Across Europe, energy performance models generally over-estimate the energy required for existing dwellings and under-estimate energy consumption in newly built, high-performance housing, inducing the terms; shortfall, prebound, rebound, take-back and comfort factor [1–5]. Calls have been made for more empirical evidence on the heating practices of occupants to determine whether the space heating assumptions within the models' are being adhered to in practice [6].

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This study explores wireless sensor measurements, covering two full heating seasons, to determine the actual heating hours (derived from the electrical supply to the central heating systems) and average room temperatures in both the main bedroom and living rooms in up to 67 rural, and rural town dwellings, in an area of North Tipperary in Ireland [7]. The data set collated under the EU co-funded Sustainable Energy for the Rural Village Environment (SERVE) project is one of the largest real-time monitoring samples on domestic household energy, of its kind, in Ireland to date.

The privately owned and mostly detached homes, built between 1970 and 2003, were retrofitted to high standards of insulation and 72% of homeowners opted to install (either or both) a new central heating boiler or high efficiency solid-fuel stove (as a secondary heater): some homeowners availed of additional grants to install new windows, LED lighting and advanced heating controls, improving the Building Energy Rating (BER) of the homes from between D2 and G (260 kWh/m^2 to >450 kWh/m^2) to predominantly B2 to C2 (100 kWh/m^2 to 200 kWh/m^2). All homes used oil-fueled central heating as their primary space heating device and most households (>50%) indicated their preference to use a secondary heating source on all or most days. While previous research has discussed space heating behaviour from large scale utility bill analyses or on results from monitoring over a short time period of weeks or months, this research has two full heating seasons of data to work with, and so the focus has been on overall heating-season patterns and statistics, to compare with the assumptions held in the DEAP model.

DEAP assumes that homes in Ireland are heated to 21°C in the living area and 18°C in the rest of the home by an ideal space heating device, for eight hours on each day of a 243-day heating season. The required energy to achieve these temperatures, during the eight heating hours, is then apportioned between a primary and secondary heating system in a ratio of 9:1.

This paper proceeds to identify the relevant research into the gap between measured and calculated household energy consumption and compares works on measured space heating durations and room temperatures in domestic households, from studies in Ireland and in the neighbouring UK. The methodology behind the space heating aspect of the DEAP model is explored, followed by the results from the analyses on the extensive datasets, and the measured room temperatures and heating schedules are compared to the standard assumptions in the asset model.

The first heating season (HS1) ran from October 2011 up to May 2012 (eight months) and the second heating season (HS2) was over the same time period the following year. The contrasting warm (HS1) and cold (HS2) heating seasons, were of benefit to this study, being above and below the long term average (LTA) outdoor air temperatures, however, the monitoring phase coincided with an economic recession and oil prices were high which may have affected homeowners' heating practices.

Nomenclature

BER	Building Energy Rating
DEAP	Dwelling Energy Assessment Procedure, Ireland's official procedure for calculating energy performance certificates
HS1	Heating season 1 (1st October 2011 to 31st May 2012)
HS2	Heating season 2 (1st October 2012 to 31st May 2013)
LaT	Living area temperature
RoHT	Rest-of-home temperature
hsav	heating season RoHT where temperatures were firstly averaged across the heating season at each hourly interval
dayav	heating season RoHT using the average of the *x* hottest hours from each day, for each house

2. Studies on space heating and energy consumption in households

The existence of a gap between the calculated and measured energy consumption in domestic dwellings has been recognised in several European countries despite differences in the building physics models and the assumptions therein [6]. While household energy consumption can vary widely between homes, almost all studies, conducted on large samples of existing dwellings, concluded that less energy was being consumed than the models' predicted [2,8–