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Case studies of cavity and external wall insulation retrofitted under the Irish Home Energy Saving Scheme: Technical analysis and occupant perspectives

Aimee Byrne [a,*,1], Gerry Byrne [b], Garrett O'Donnell [b], Anthony Robinson [b]

[a] Department of Civil, Structural and Environmental Engineering, Trinity College Dublin, Ireland
[b] Department of Mechanical and Manufacturing Engineering, Trinity College Dublin, Ireland

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ABSTRACT

The residential sector represents 27% of primary energy consumption in Ireland. This paper examines the case study of the Irish government's national grant scheme to encourage energy efficiency retrofit in private housing. That is the Home Energy Saving (HES) Scheme, later rebranded the Better Energy: Homes (BEH) Scheme. The methodology involved monitoring several homes immediately before and after retrofit alongside discussions with occupants. The examination focused on specific measures commonly introduced through the HES/BEH programme – cavity and external wall insulation. It has been found that a significant decrease in heat loss through the walls was measured in all cases. Regardless, the occupant played a considerable role in the change in energy use in the buildings, and the main motivation for retrofit was found to be comfort and not energy savings or environmental concerns. As a result, the actual energy savings are notably less than the potential savings had the pre and post comfort levels remained the same.

1. Introduction

1.1. Background to the scheme

Globally, improving energy efficiency in new and existing buildings "encompasses the most diverse, largest and most cost-effective mitigation opportunities in buildings" [1]. The largest potential of carbon savings by 2030 is attributed to retrofitting existing buildings and replacing energy using equipment due to the slow turnover of the stock. It is imperative that realistic measures of potential savings within this energy sector be quantified. 2011 figures show the residential sector to be 27% of the total primary energy consumption in Ireland [2].

The Sustainable Energy Authority of Ireland (SEAI) launched a Fund Disbursement Programme in February 2003, later rebranded as the Warmer Homes Scheme (WHS) [3] focusing on alleviating fuel poverty and supporting energy efficiency in low income homes. In 2006, the Greener Homes Scheme (GHS) was launched offering grants to homeowners for the installation of renewable technologies. In 2008, SEAI launched the Government's Home Energy Saving (HES) pilot scheme [4] with full rollout in 2009 offering grants to supplement the cost of energy saving features in the home.

In May 2011, the Better Energy Programme replaced the three private residential retrofit schemes. The GHS effectively ended, although solar heating support was continued along with the features offered under HES under one scheme, branded the Better Energy: Homes (BEH) scheme, with most grant levels reducing by 20% later that year. The WHS was subsequently rebranded the Better Energy: Warmer Homes (BEWH) scheme. At the beginning of the research and monitoring for this article, grants were at the original level shown for the HES scheme in Table 1 but part way through the testing period the grant levels are as shown for the BEH scheme in the same table.

1.2. Energy use in the home

The determinants of home energy use are complex. It is the product of interaction of occupants, the building, equipment and climate leading to different behaviour and energy use [5]. Occupant factors include, age, income, education, gender, awareness and comfort. Building factors include size, type, age and location.

* Corresponding author.
E-mail addresses: aimee.byrne@dit.ie (A. Byrne), gerbyrne@tcd.ie (G. Byrne), garret.odonnell@tcd.ie (G. O'Donnell), arobins@tcd.ie (A. Robinson).
[1] Present address: School of Civil & Structural Engineering, Dublin Institute of Technology, Bolton Street, Dublin 1, Ireland.

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Table 1
Grants available through the HES and BEH schemes.

Measure	HES 2009–2011 grant	BEH 2011–2015 grant
Roof Insulation	€250	€200
Cavity wall insulation	€400	€250
Internal Wall Dry-Lining	€2500	• Apartment (any) OR Mid- terrace House €900 • Semi-detached or End of Terrace €1350 • Detached House €1800
External wall insulation	€4000	• Apartment (any) OR Mid- terrace House €1800 • Semi-detached or End of Terrace €2700 • Detached House €3600
High Efficiency Gas or Oil fired Boiler with Heating Controls Upgrade	€700	€560
Heating Controls Upgrade	€500	€400
Solar heating	Available under GHS	€800
An after works Building Energy Rating (BER) assessment must be completed	€200	€50

Each of these impacts energy use in the home [6–13]. Historically in Ireland, building design mainly focused on meeting aesthetic and functional needs over thermal performance of the design. The first national building standards in Ireland were introduced by the Building Control Act of 1990 [14]. 74% of dwellings in Dublin were built before the first Building Regulations in 1991 [15]. Part L of the Building Regulations was first introduced more recently in 2005 [16]. It refers to the conservation of fuel and energy giving minimum requirements for energy efficiency standards and Building Energy Rating (BER) grades for new buildings as well as change of use and material alterations of existing buildings. Energy efficiency, thermal comfort and sustainability are more recent trends as highlighted by the shift in political and industry discourse in Ireland. The propensity of occupants to undertake energy efficiency retrofits in their home is dependent on a similarly long list of interacting factors [14–21]. It is thus understandable why the potential energy savings due to retrofit are difficult to quantify with any degree of accuracy since it relies on such a large and typically uncontrolled number of variables [22].

When it comes to energy retrofits in Irish homes, grants for insulation constitute the highest pay-out by SEAI [23]. Moreover, according to the EU Action Plan for Energy Efficiency, wall and roof insulation offer the greatest opportunity to save energy and reduce emissions in this sector [24]. The scope of this project was therefore reduced to homes receiving either cavity wall or external insulation due to limitations in resources and with the aim of limiting variables. A few basic concepts of energy use in the home must first be understood before describing the methodology designed for this study.

1.2.1. *Heat flow through the building envelope*

One-dimensional, steady-state models can be used to represent the plane or composite wall [25], or other building envelope material. Heat is transferred to the wall's inner surface by convection from the warm air, by conduction through the wall, and by convection from the outer surface of the wall exposed to the cold air. In the case of Fig. 1 the 'hot air' is the internal heated space and the 'cold air' is the external colder ambient air. In a simple steady-state scenario, where the one-dimensional thermal resistance network model is applicable, the heat transfer can be estimated provided that each thermal resistance can be approximated and the interior and outdoor temperatures are known. Of course, increasing one of the thermal resistances or the addition of an additional thermal resistance will increase the overall thermal resistance and thus reduce the heat transfer for given indoor and outdoor conditions. Since the rate of heat transfer dictates the net energy transfer over a given time period, retrofit measures are aimed to reduce the rate of heat transfer, typically by the addition of a layer of insulation, such as external wall or roof insulation, or filling a wall cavity will insulating material.

Although steady one-dimensional models give insight into the expected thermal behaviour of building envelope material and are simple to use and implement in predictive calculations, they may not in all cases be physically representative of the actual thermal phenomena. Many heat transfer scenarios are time dependant, or transient. Transient effects must be considered when boundary conditions change at a rate which is faster than that which the building envelope can respond. Walls, or indeed other building envelope types, with high thermal mass have the capacity to store and release heat which changes the dynamics of the heat transfer and energy flow compared with steady or quasi-steady systems [26–28]. Thermal admittance is a measure of a material's ability to take in and store heat from a space and releasing it back to the space over time. It is therefore an indicator of the storage capacity of that material. In reality, buildings rarely achieve steady-state conditions as internal and external environments fluctuate, usually cyclically, faster than the envelope material can respond [26,29]. This leads to transient heat transfer within the wall. The implication is that, when considering the influence of thermal insulation on the overall influence of energy flow through building envelope material, significant error can occur on any subsequent energy analysis when steady thermal network models are imposed on inherently

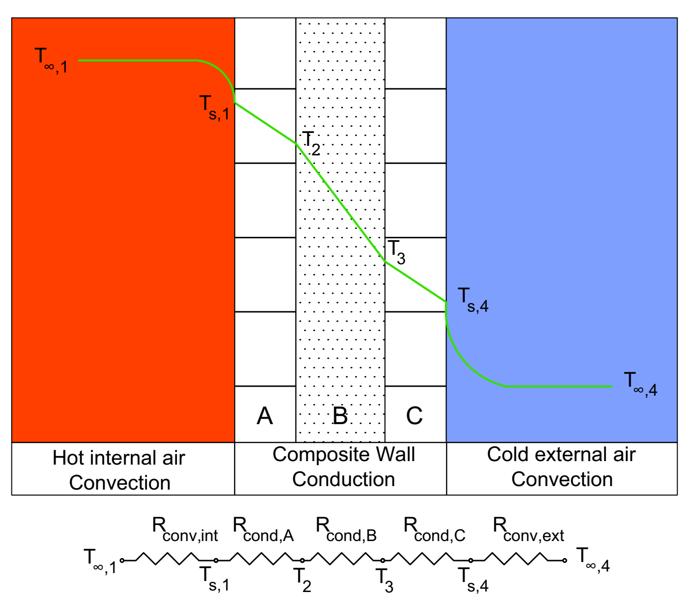

Fig. 1. Thermal network representing heat flow through a generic composite wall system made up of 3 materials, A–C.