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Retrofitting of homes for people in fuel poverty: Approach based on household thermal comfort

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ABSTRACT

In a context of fuel poverty, the application of cost-effective methodology for energy retrofitting of buildings is ineffective. In these situations, there is no energy consumption reduction and thermal comfort is hardly achieved. This paper introduces a methodology to choose the most appropriate retrofit measure in a context of fuel poverty. This methodology is based on thermal comfort as the main criterion, and secondarily, it is based on the budget for paying monthly energy bills and initial costs. This study demonstrates how thermal comfort and monthly available income of households must be the first criterion for decision-making process. The methodology has been applied in four buildings. Results demonstrate why active retrofit measures are ineffective when monthly budget to pay energy bills is reduced. In conclusion, recommendations are made to promote efficient public policies in energy retrofit. The study was supported by the European Regional Development Fund (ERDF) and carried out within the research project '{Re} Programa. (Re)habitation +(Re) generation +(Re)programming' during 2013–2015.

1. Introduction

Building energy retrofitting has been encouraged by European institutions since 2002, when the first Building Energy Efficiency Directive was released (European Parliament, 2002). The cost-effective methodology was produced (European Parliament, 2010) by selecting the retrofit measures which achieve the greater energy reduction at lowest cost. Although this methodology is appropriate for many cases, it is inefficient when occupants have limited economic resources and fall into fuel poverty.

A person is said to be in fuel poverty when they have to pay more than 10% of their incomes for all the energy services, a threshold above which spending is considered disproportionate (Boardman, 1991). More than 124 million people within the European Union are considered to be in fuel poverty (Atanasiu et al., 2014). Not achieving thermal comfort inside houses leads to the decrease of quality of life and eventually to health issues (Ormandy and Ezratty, 2012; World Health Organization, 1991). Therefore, this current study is focused on energy retrofitting of residential buildings where people live in fuel poverty.

The lack of access to energy has different implications among different regions of the world. Thus, to determine the geographic boundaries, it is important to differentiate between the concepts of energy poverty and fuel poverty.

Studies carried out in developing countries relate energy poverty to the lack of access to energy (Chaurey and Chandra, 2010), and they are often based on rural settlements lacking in infrastructure. These studies are mainly focused on the electrification of rural regions, the availability of energy and economic resources (Azoumah et al., 2011; Bhide and Monroy, 2011), and on social issues such as gender equality or health improvements (Kaygusuz, 2011). In these countries, a direct connection has been demonstrated between energy access, health, education, productivity and incomes (Bridge et al., 2015; Hodbod and Adger, 2014).

Studies of fuel poverty within developed countries are based on urban and rural environments where the electrification rate is high. These studies relate fuel poverty to the inability of building occupants to afford to pay energy bills. The aims of this study consist on reducing energy consumption through retrofit measures and managing public allowances.

Within the European countries, a heterogenic response can be found to fuel poverty issue. In the case of England (Hamza and Gilroy,

Abbreviations: FPR, Fuel Poverty Retrofit; E_N, Needed energy demand; E_B, Balanced energy demand; E_P, Purchased energy for HVAC (kW h); μ_i, HVAC efficiency of the system according to each retrofit measure; E_R, Energy demand reduction according to each retrofit measure (kW h); E_i, Energy demanded from the retrofitted building scenario; TCP, Thermal Comfort Percentage

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2011), a study has been conducted on connecting the ageing of the population and home energy consumption. As older population is predicted to increase, it will notably affect future energy consumption due to the longer periods people stay at home. By 2026, 75% of the occupants who live in their own properties will be over 65 years of age (DCLG and DWP, 2008, p. 29).

A study conducted in Germany in 2010 (Grösche, 2010) demonstrated that the existing allowance scheme for low-income households, which covers the house as well as the space heating cost, will continue producing energy building inefficiency. This study shows that there is a connection between low rents and buildings with a poor energy performance. In Germany, low rents receive allowances. If the landlord retrofits the building, also improving energy efficiency, then rent might be higher. However, tenants prefer lower rent buildings, even though less energy efficient, to take advantage of the allowances. The consequence is that the owners will not retrofit their houses.

Another study has been conducted in Bulgaria (Bouzarovski et al., 2012) on the implementation of the EU Directive. This study shows that despite the political will to implement allowances that assure energy efficiency, there is no motivation to create long-term policies which take into account all the dimensions of the issue.

A study examined the connection between ageing of the European population and conservation of the buildings in Spain (Barrios et al., 2015). This study examined how older people often have low incomes and cannot afford to invest in retrofitting their buildings. However, current quality of the buildings will not allow them to age in appropriate conditions and lead comfortable, healthy and secure lives within their own homes.

Finally, there is a study which connects fuel poverty and climate change mitigation policies (Ürge-Vorsatz and Tirado Herrero, 2012) via the monetization of greenhouse gases. This will lead to the increase of energy prices and the deterioration of the socio-economic situation.

Among the above studies, it has been noted that the relationship between energy performance, comfort and low-incomes has not yet been effectively addressed. In addition, the cost-effective methodology (European Parliament, 2010), released by the European Commission, is not appropriate in those cases where the households have low-incomes. This relationship between cost-effective methodology and low-income households is discussed in depth in Section 2.

Moreover, improving access to energy and achieving a higher energy system efficiency will allow people to increase their comfort, health and security levels. According to a study carried out by Sovacool (2012), investing in political and social issues alongside technical development is needed to deliver real benefits to society. It is worth considering where greater efforts are needed, whether in political or technical issues.

Factors within Fig. 1 define the scope of this work and the theoretical framework. This study proposes a methodology to assess how retrofitting of buildings with low-income households might improve thermal comfort in buildings, and quality of life of the people. In addition, further discussion is proposed on the implication of applying the cost-effective methodology.

The cost-effective methodology is often used to choose the best retrofit measure, and this may be applicable in many cases. However, this methodology is based on assumptions that do not fit within a context of fuel poverty. As explained below, the application of this methodology could lead to misunderstandings among professionals and public institutions regarding the implementation of some retrofit measures. Following on from this section, a different methodology is proposed for households in fuel poverty.

2. Cost-effective methodology and fuel poverty

Cost-effective methodology is widely used and highly promoted by the main European Directives: the "2010 Energy Performance of Buildings Directive" (EPBD) (European Parliament, 2010) and the

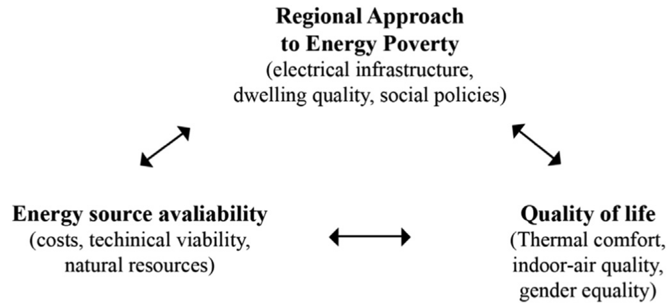

Fig. 1. Factors of the fuel poverty. Source: prepared by the authors.

"2010 Energy Efficiency Directive" (European Parliament, 2012). This methodology is entirely appropriate for many cases, however, when people are in fuel poverty the main methodology assumptions are not applicable. An analysis of those inapplicable assumptions has been made below.

Firstly, energy use profiles were differentiated according to the definition given in the EPBD 2010. As discussed in Sections 2.1, 2.2 and 2.3, the implications of these definitions makes the cost-effective methodology inapplicable in a context of fuel poverty.

- *Users in 'Typical Use'* are defined, according to the EPDB 2010/31/EU, as those users which carry out all the needed and reasonable actions to satisfy their thermal comfort during the whole year (European Parliament, 2010).
- *Users in 'fuel poverty'* are those whose spending for energy services are considered disproportionate, normally more than 10% of their incomes (Boardman, 1991).

Currently, building retrofit measure appraisals have been done without distinguishing socio-economic situation of the end user. However, defining end users with regard to what they can afford is a key factor in the effective implementation of public policies (Dubois, 2012). Moore (2012) showed that small changes regarding the definition of fuel poverty lead to significant variations in who will receive the allowance among end users. To consider the importance of socio-economic situation of end users, a study have been conducted (Walker et al., 2014) to propose a user distribution according to their incomes, and whether those people will be taken out of their fuel poverty situation after a retrofit of their buildings.

The retrofit measures evaluated for both user profiles are often the same, however, cost-optimal results are not always applicable, as analysed in the following Sections 2.1, 2.2 and 2.3. De Luxán García de Diego et al. (2015) analysed the paradox that some studies, which did not consider the user profile, concluded high energy reductions for a building, when there was actually no consumption because household could not afford to pay for it in the first instance. This misunderstanding might lead to ineffective decisions and eventually ineffective policies.

2.1. Energy performance definitions

The calculation method for cost-effective methodology can be found within Article 2 of the EPBD as: *4. 'energy performance of a building' means the calculated or measured amount of energy needed to meet the energy demand associated with a typical use of the building, which includes,* inter alia, *energy used for heating, cooling, ventilation, hot water and lighting"* (European Parliament, 2010, p. 153).

The above paragraph states that the occupancy profile is defined as "typical use" for the calculation of building energy demands. However, the user in fuel poverty has a limited budget for energy bills, and this amount is not enough to pay for the total fuel cost required to reach the range of thermal comfort. Therefore, occupancy profile cannot be