# EPBD assessment as a tool for fuel poverty estimation

Sara Magalhães and Vítor Leal
IDMEC, Faculty of Engineering, University of Porto, rua Dr. Roberto Farias, 4200-465 Porto, Portugal

**ABSTRACT**

This paper explores the potential use of the Energy Performance of Buildings assessment schemes developed after the EPBD to perform estimates of fuel poverty in countries, under the nominal conditions of their certification schemes. The methodology is applied to Portugal as an example, considering the UK definition of fuel poverty as the condition in which the fraction of household income necessary to endure energy services is higher than 10%. The results show that the fuel poverty rate in mainland Portugal preliminary estimated under nominal conditions approaches 92% in the Reference case Scenario, if considering a tariff of 0,089€ per kWh of energy supplied. The changes like to occur due the adoption of less stringent conditions than the nominal ones are discussed. Although the application of the method is illustrated with the Portuguese case, it is believed that it could be also easily applied or adapted to other countries.

## 1.INTRODUCTION

According to Boardman, B., (1991), a household is said to be in fuel poverty if it needs to spend more than 10% of its (disposable) income on household fuel (energy), including heating the house to acceptable WHO levels [1]. It should be noted that this objective approach is not intended to measure whether households *in fact* are spending more than 10% of their income on domestic fuel, but rather whether they *would need* to do so in order to achieve acceptable warmth levels in their dwellings [2]. Whether a household is in fuel poverty or not is determined by the interaction of a number of factors, but three specifically stand out [1]. These are:

- The energy needs of household (influenced by the energy efficiency status of the property);
- the cost of energy, and;
- household income

There are strong associations between inadequately heated homes and increased rates of morbidity and mortality [3], and policy makers worldwide are paying increasing attention to indoor living environments, as a consequence of a growing body of evidence linking buildings to human health [4]. The fact that Portugal is among the European countries where the excess of mortality rate and hospital episodes in winter over summer is among the highest [5] adds to the suspicion that the households are not heating their homes adequately. This could be related to a high rate of fuel poverty, despite the traditional yet often misleading idea that because the country has “a mild climate” heating is not a serious problem.

Addressing the need to characterize fuel poverty in a wide geographical scale, with limited budget resources for on-site monitoring, this paper explores the potential of the use of the Energy Performance Certification of Buildings schemes developed after the EPBD [6] to perform estimates of fuel poverty in countries, taking mainland Portugal as an example of application. The European EPBD was transposed into Portuguese legislation in 2006 through three Decrees and its implementation was divided into three phases from 2006 to January 2009 (Decrees 78/2006, 79/2006 and 80/2006). Since all EU countries now have certification schemes in place, with thousands of buildings from all ages assessed, a method based on this data could be interesting since it has a very large sampling of the existing buildings, covering all construction ages, and available at nearly no additional cost (ie, the data already exists).

## 2.METHODOLOGY

The method is based on the following major steps:

1. Characterization of the average nominal space heating needs of housing building stock, per slot of age of construction, using the database of the National Energetic Certification System (SCE), which constitutes the transposition of the EPBD into Portuguese law; Nominal means the space heating needs necessary to maintain indoor temperatures at a constant level of 20 ºC during winter season;
2. Characterization of the average actual “other energy needs”, apart from space heating energy needs, of housing building stock based on data collected from the National statistical entities INE/DGEG (2010);
3. Characterization of the distribution of financial income of households, based on INE (National Statistics Institute) statistical data;
4. Conflation of the data gathered in steps above to achieve a first estimation of the fuel poverty under SCE nominal conditions, in accordance to UK fuel poverty definition, presented in Equation 1.

The estimation of fuel poverty was performed for a Reference case Scenario (0,089 €/kWh) and for a sensitive analyses, which considered four different fuel tariffs scenarios: 0,025; 0,05; 0,1 and 0,15 €/kWh of energy delivered. The fuel poverty ratio can be estimated by:

$$Fuel\_Poverty\_ratio = \frac{(nominal\_space\_heating\_needs + actual\_"other\_energy\_needs") \times energy\_price}{income} \quad (1)$$

*Energy needs (i.e. nominal space heating needs and actual “other energy needs”) [kWh/year]*
*Energy price [€/kWh]*
*Income [€/year]*

### 2.1 Characterization of the nominal space heating needs of the housing building stock

The database of the National Energetic Certification System (SCE) was accessed from ADENE (Agência para a Energia, the issuing authority for building energy certification in Portugal). Each certificate represents an autonomous fraction (i.e., an apartment or a detached dwelling). For the purpose of this work only the existing buildings and the new ones already completed were considered to be a part of our housing stock sample (ie, the new buildings still not completed were left out). For each certificate, information regarding the respective area (m$^2$), nominal space needs (Nic) (kWh/m$^2$.year), number of bedrooms [0 - >7 bedrooms] and year of construction [<1900 – 2011] was extracted from the database for the mainland Portugal and treated to exclude obvious typing or similar errors. This housing stock sample represents 7% (259775 certificates) of the total household classic habitual residence for 2010 (3773955) [7].

A total weighted average of the nominal Nic value (kWh/year) for a typical household was obtained for the total housing stock sample, considering the distribution of the entire mainland Portuguese housing building stock per number of bedrooms and year of construction, which was based on INE´s statistical data. Figure 1 presents the weighted average nominal heating needs (Nic) values (kWh/year) per year of construction of the housing stock sample for mainland Portugal. The sample was assumed to correspond to autonomous fractions that are private and currently occupied. In general, all INE´s statistical data was referred to year 2011, where earlier years were assumed when data not available.


**Figure 1.** Weighted average nominal heating needs (Nic) (kWh/year) per household per year of construction of the housing stock sample for mainland Portugal (based on ADENE´s database)

The weighted average value for nominal space heating needs for a typical mainland Portuguese household is 18.870 kWh/year. Because this value is related to useful energy, there was the need to estimate the final energy value of 28.282 kWh/year, assuming an average conversion final to useful technology efficiency of 67%.

**2.2 Characterization of the actual "other energy needs"**

The actual average annual energy consumption values for each "other energy needs", such as domestic hot water, cooking, electrical equipment and lighting, for a typical mainland Portuguese household in 2010, were collected from the INE/DGEG 2010 report [7]. These were: 1.710, 2.873, 802 and 326 kWh/year, respectively. It was assumed that these values are a good representation of the entire housing building stock.

**2.3 Calculation of energy bill for each tariff scenario**

All the energy end users' values (the space heating nominal value, estimated in section 2.1, and the actual energy consumption values for the domestic hot water, cooking, lighting and electrical equipment, estimated in section 2.2) were multiplied by an average tariff based on the 2012 gas and electricity tariffs of EDP (0,089 €/kWh), which represents the Reference case Scenario. This gave us the average annual energy bill of 3025 €/kWh.year. for a typical mainland Portuguese household for that tariff scenario. For the electricity tariffs, average values considering low peak demand hours and the use of heat pumps were assumed. Since fuel prices were pointed by some authors [8] as the main underlying cause of the increase in fuel poverty since 2003, in order to study how the fuel poverty rate would vary with tariffs, four scenarios were developed for the sensitive analyses.

**2.4 Characterization of the distribution of financial net income of households**

The 2009 annual gross income variables (Figure 2, left hand side), collected from the INE´s statistical data, were used in terms of net income, which is the income net of tax and National Insurance (i.e. considering income deductions). The 2009 annual gross income data was itself corrected with values from 2010 (total 394227 households in 2010) and to include also the % of households covered by the National Insurance help, which haven't been considered. Additionally, for calculations, the average values of each income tier were used instead (e.g. for the tier 0-5000 €/year the average value is 2500 €/year). Similarly, the income deductions were valued based on additional INE statistical data and estimations were used when data was not available. In general, all statistical data was referred to mainland Portugal but when data was not available, Portugal data was used instead. The same is for the year 2011, where earlier years were assumed.

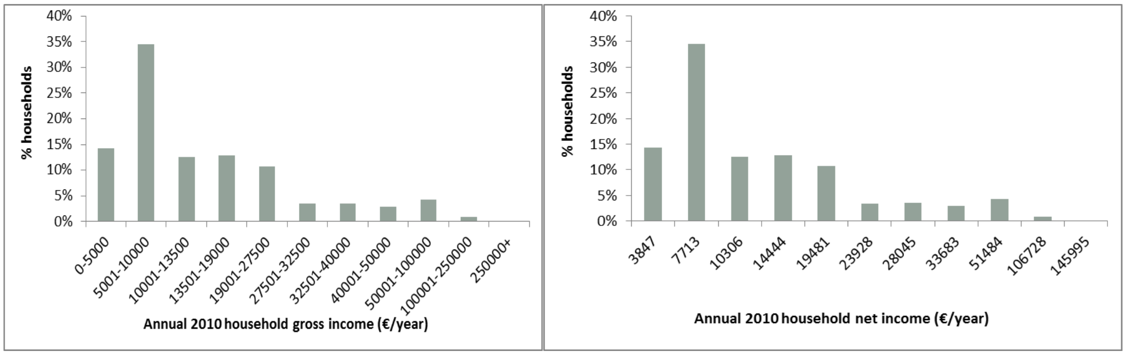


**Figure 2.** Distribution of the annual 2010 gross income (left-hand side) and annual 2010 net income (right-hand side) per households for mainland Portugal

**2.5 Estimation of Fuel poverty rate for the Reference case scenario and the sensitivity analysis**

Conflation of the energy bill, calculated in section 2.3, and net income of households data, presented in Figure 2 (right-hand side) in section 2.4, was obtained to achieve a first estimation of the fuel poverty under SCE nominal conditions for different tariff scenarios (i.e., Reference case scenario and sensitivity analysis). For the purpose of this work it was assumed that the average energy bill (3.025 €/kWh.year), of a typical household, is the same for each type of net income tier (as presented in Figure 2, right-hand side), and therefore, this energy bill unique value will be divided by each net income tier to result in different fuel poverty ratios. The fuel poverty rate was then estimated by summing the percentages of households within the net income tiers (as presented in Figure 2, right-hand side), that would have resulted in a fuel poverty ratio higher than 10%.

**3.RESULTS and DISCUSSION**

Figure 3 shows the accumulative frequency on total households by percentage of nominal[1] income spending on energy bills in the Reference case Scenario. From the results of this figure, it is possible to verify that the preliminary estimation of fuel poverty rate from the Reference case Scenario, under nominal conditions, resulted in that 92% of households from mainland Portugal are living under conditions of fuel poverty, i.e. where families would need to spend more than 10% of its income on fuel to maintain the nominal level of warmth (20ºC during all winter) and to meet its other actual energy needs (Figure 3).

In terms of the sensitivity analysis, as expected, it was found that energy price have a very significant impact on the % of households living in fuel poverty conditions. Higher energy tariffs imply higher fuel poverty rates. However, the evolution is not a linear one, and tariffs with values higher than 0,089 €/kWh will not reflect in higher increases on fuel poverty rate, as it reaches saturation levels, whereas, tariff levels of 0,025€ per kWh of energy delivered could actually reduce nominal fuel poverty rate to 50% (Figure 4).

[1] Here, nominal income definition is used as it is the % of income that would be necessary to spend on the energy bills to include the nominal space heating at a constant temperature of 20ºC during winter season. To bear in mind that it does reflect the actual income spent on energy bills.

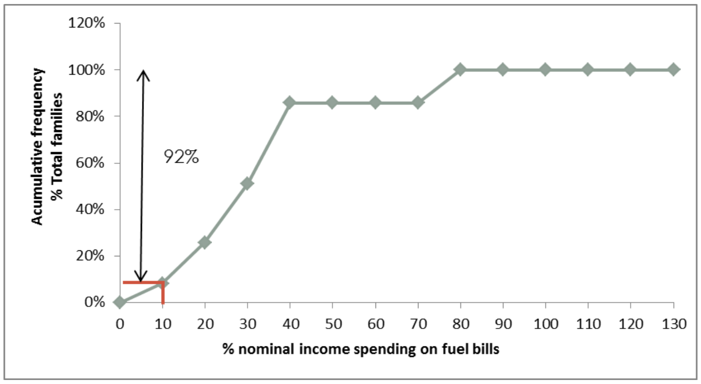


**Figure 3.** Accumulative frequency on total households by % of nominal income spending on energy bills in Reference case Scenario

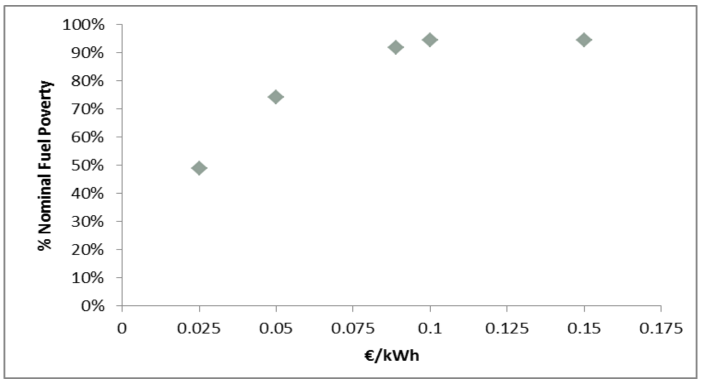


**Figure 4.** Sensitivity analysis: Nominal fuel poverty estimation rate for different energy tariffs (Reference case Scenario and Scenarios 1-4)

## 4.CONCLUSIONS

The present work preliminarily established a method which uses the Energy Performance Certification schemes developed after the EPBD to perform estimates of fuel poverty in countries. With this methodology, the fuel poverty rate under nominal SCE conditions in mainland Portugal was preliminary estimated to be 92% in the Reference case Scenario, considering a tariff of 0,10€/kWh. It is worth to mention that with this work there is no intention of evaluate future fuel poverty trends, but only estimating the current value for mainland Portugal.

The sensitivity analysis to the energy prices showed that the level of cost of the energy delivered that would decrease nominal fuel poverty to a relatively low level is around 0,025 €/kWh. This value is only within the reach of very efficient heat pumps, or forms of woody biomass if used in high efficiency furnaces. The alternative way to decrease fuel poverty, besides increasing the income, is to improve the energy efficiency of the housing building stock, although this is a huge challenge regarding dimension and time-to-effect.

Although the application of the method is illustrated with the Portuguese case, it is believed that it could be also easily applied or adapted to other countries, helping in the development of energy policies intended to reduce fuel poverty, most notably through enhancing the energy efficiency of targeted housing stock.

A final word to address the issue of nominal conditions, which for the SCE means heating the full house at 20ºC during all winter. While the ready availability of data made this a convenient starting point, the estimated fuel poverty rates would be lower if more realistic nominal space energy needs, considering for example realistic occupancy  schedules, should be used instead.

**REFERENCES**

[1] Boardman, B., 1991. *Fuel Poverty: From Cold Homes to Affordable Warmth*. Belhaven Press, London.

[2]. Fahmy, E., Gordon, D. and Patsios, D., 2009. Predicting fuel poverty at a small-area level in England. *Energy Policy*, **39**, pp. 4370–4377.

[3]. Healy, J.D. and Clinch, J.P. 2004. Quantifying the severety of fuel poverty, its relationship with poor housing and reasons for non-investment in energy saving measures in Ireland*. Energy Policy,* pp. 207-220.

[4]. Hood, E., 2005. Dwelling disparities: how poor housing leads to poor health. *Environmental Health Perspectives* **113**, A310–A317.

[5]. Healy, J.D., 2003. Excess winter mortality in Europe: a cross country analysis identifying key risk factors. *J Epidemial Community Health*, pp. 57:784-789.

[6]. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:001:0065:0071:EN:PDF

[7]. INE/DGEG, 2011. *Inquérito ao Consumo de Energia no sector Doméstico 2010*, Edições 2011.

[8]. DECC, 2009. The UK Fuel Poverty Strategy. 7th annual progress report. 2009. London, Department of Energy and Climate Change. Report number: URN 09D/353.