Fuel poverty can be defined as ‘the inability to afford adequate warmth in the home’ and it is the result of the combination of three factors: low household income, lack of energy efficiency and high energy bills. Within this context, the present research is aimed at characterizing, for the first time, the housing stock of fuel-poor households in the Autonomous Region of Madrid. Fuel poverty incidence was established and households were divided into six different groups according to their relative position regarding fuel and monetary poverty. The housing stock of each group is characterized and those households most in need are identified. These results enable energy retrofitting priorities to be established, focusing on the needs of the different household groups and accounting for their housing stock characteristics. This allows Spanish energy retrofitting policies to be assessed for their capability of tackling fuel poverty and makes it possible to suggest some improvements.

Keywords: energy consumption, energy policy, fuel poverty, housing stock, low income, retrofit, vulnerability

Introduction
Relevance of research
This research falls within the context of the European Union (EU), which has established a priority to develop an inclusive economy with a strong emphasis on job creation and poverty reduction (European Commission, 2010a). One of the targets of this strategy is the reduction of 20 million people in or At Risk Of Poverty or social Exclusion (AROPE). This concept sets the link between poverty and fuel poverty, where poverty is defined as the share of the population in at least one of the following three conditions:

- At risk of poverty, meaning below the poverty threshold (60% of the median income).
- In a situation of severe material deprivation, i.e. people who cannot afford at least four of the nine following items: 1, (arrears on) mortgage or rent payments, utility bills, hire purchase instalments or other loan payments; 2, one week’s annual holiday away from home; 3, a meal with meat, chicken, fish (or vegetarian equivalent) every second day; 4, unexpected financial expenses; 5, a telephone (including a mobile phone); 6, a colour television; 7, a washing machine; 8, a car; and 9, heating to keep the home adequately warm.
- Living in a household with a very low work intensity.

Thus it can be seen that tackling fuel poverty is framed under EU energy policies and, therefore, the real scope of fuel poverty must be appraised so as to implement the appropriate measures. Furthermore, it must be highlighted that there is a lack of this kind of research in the Spanish territory. Although some previous studies exist (European Fuel Poverty and Energy Efficiency Project, 2009; Tirado Herrero, López Fernández, & Martín García, 2012), they do not deepen the overlap between monetary and fuel poverty nor characterize the housing stock.

Aims and objectives
This paper explores the incidence of fuel poverty in the Autonomous Region of Madrid through the exploitation of available statistical data in order to evaluate the suitability of the current energy retrofitting policies. To this end, the following objectives are covered:
• to define the relationship between fuel and monetary poverty and their possible overlap
• to characterize households' building stock in relation to their position regarding monetary and fuel poverty
• to advance the knowledge of priority housing stock renovation according to household fuel poverty conditions
• to determine the main limitations of the current Spanish energy retrofitting policies to tackle fuel poverty

Fuel poverty
Definition and measurement
The fuel poverty concept has its origin in UK, where the Warm Homes and Energy Conservation Act (UK Parliament, 2000) defined it as follows:

a person is to be regarded as living ‘in fuel poverty’ if he is a member of a household living on a lower income in a home which cannot be kept warm at reasonable cost.

In order to establish a measurement method, the UK Department of Trade and Industry (DTI) (2001) followed Boardman’s (1991) definition in which a household suffers from fuel poverty when it is unable to have adequate energy services for 10% of household income. Thus, the fuel poverty ratio (FPR) is defined as:

\[
FPR = \frac{\text{fuel costs} \times (\text{modelled usage} \times \text{price})}{\text{income}}
\]

where fuel costs includes heating, hot water, lighting and other energy services. The adequate level of warmth for heating is defined as 21°C for the main living area and 18°C for other occupied rooms, based on recommendations by the World Health Organization (WHO) (1987). If this ratio is greater than 0.1, then the household is considered fuel poor.

Nevertheless, Hills (2012) questioned this fixed threshold and proposed a new approach. He proposed that households suffer from fuel poverty when the energy cost of ensuring adequate warmth is above the average, and the remaining income, after payment of bills, is below the official poverty line. This approach, called the Low Income High Cost Definition, is the new legal framework to monitor fuel poverty in England (DECC, 2014).

As the traditional threshold of 10% of household income made it difficult to extrapolate it to the rest of Europe and to make any comparative analysis amongst European countries, Healy and Clinch (2002b) proposed a new consensual approach based on six social indicators of fuel poverty. These indicators were taken from the 1994–2001 European Community Household Panel (ECHP) (European Commission, 1994), and are combined into a consensual approach to fuel poverty by analysing subjective and objective data on the presence of mould, lack of central heating and the ability to keep warm. The ECHP survey criteria, conducted by EUROSTAT, was incorporated in 2004 into the European Union Statistics on Income and Living Conditions (EU-SILC) and remains in force. This study defined the characteristics of households that made them more vulnerable to fuel poverty: single-parent families, especially those with children under 16 years of age and pensioners, living in an apartment block, separated, divorced or widowed individuals, those with a poor education, the unemployed and social service beneficiaries, and, finally, tenants.

Finally, the Commission Working Paper ‘An Energy Policy for Customers’ (European Commission, 2010b) establishes that fuel-poor households could be defined as those that:

spend a higher proportion of their total expenses on energy products than a proposed threshold value […] close to the double of the national average ratio number.

It is important to note that these studies included no evaluation of fuel poverty related to high temperatures or cooling requirements, although southern European countries (Portugal, Spain, Italy and Greece) still showed the highest levels of fuel poverty (Healy, 2004). Earlier methods were strictly concerned with the inability to achieve adequate warmth in cold months, and it is thus necessary to start working on new approaches to fuel poverty in southern European countries. In line with that (it must be highlighted as a spearhead research in this field), some studies carried out in Greece (Santamouris et al., 2007; Santamouris, Paravantis, et al., 2013), in which the relation between fuel poverty, low income and housing stock characteristics was stated, showed higher levels of fuel poverty among low-income households, presumably caused by the low thermal performance of the envelope. Furthermore, poor indoor thermal conditions in low-income dwellings during heatwaves and cold winters were demonstrated in Athens (Sakka, Santamouris, Livada, Nicol, & Wilson, 2012; Santamouris, Alevizos, et al., 2013).

Fuel poverty studies in Spain
Although the concept of ‘fuel poverty’ is yet to be officially defined in Spain, some studies in recent years have tried to evaluate the incidence of fuel poverty in Spain. This is the case of the European Fuel Poverty
and Energy Efficiency Project (2009), which consisted of a cross-sectional analysis in France, Belgium, the UK, Italy and Spain using EU-SILC and followed the method developed by Healy and Clinch (2002b). This research defined the incidence of fuel poverty as well as its relationship to urbanization level, building types, tenure status, family composition, household income and fuel poverty.

The aim of the European Energy Ambassadors project (Ecoserveis, 2009), another relevant study in Spain from 2009, was to develop practical, sustainable solutions to fuel poverty and achieve energy savings in households through the mediation of social workers. In the REPEX project (Tirado Herrero et al., 2012), fuel poverty in Spain was studied using two available methods: one based on income and expenditure, like the UK existing one, and the other based on households’ self-perception, developed by Healy and Clinch (2002a). Fuel poverty was first studied using the income and expenditure method. In Spain, there is no equivalent to the English Housing Survey, and the study used in this research was the EPF (Family Budget Survey), which evaluates real, not estimated, expenditure, and therefore does not reflect households that are unable to afford adequate warmth. Results for 2010 showed that approximately 12% of Spanish households were spending more than a 10% of their income in energy bills and thus they were considered to experience fuel poverty conditions. The second method used the EU-SILC for Spain, which collects answers by household members and thus yields quite subjective results. However, as mentioned above, this is the only approach that permits pan-European transnational studies. Results from this approach showed that water leaks and dampness had the greatest impact on fuel poverty measures, affecting almost 20% of surveyed households. In 2010, around 7% were found to be unable to afford adequate warmth during the cold months.

Both national and regional data from REPEX were presented. According to the income-expenditure method, the regions with the highest level of fuel poverty were the coldest ones, although according to the self-reporting method the poorest areas were the most temperate ones. This apparent paradox could be explained by a lower energy efficiency in southern dwellings or differences in householders’ self-perceived comfort temperatures.

The few studies on fuel poverty carried out in Spain have highlighted the need for more knowledge about this field. Furthermore, these studies do not properly reflect the climatic variation between northern and southern Spain. Given that all studies are related to cold temperatures, fuel poverty caused by high temperatures should also be explored. In Spain, differences between cooler and warmer regions undoubtedly lead to a diversity of fuel poverty situations.

### Relevant energy policies regarding Spanish fuel-poor households

The EU has taken some steps forward in this field. The Third Energy Package for the energy market legislation included two directives related to electricity and the gas market: 2009/72/EC (European Parliament, 2009a) and 2009/73/EC (European Parliament, 2009b), which brought in what it called ‘vulnerable clients’, a concept that should be defined by each country. Simultaneously, in Spain the social bonus was implemented that froze electricity prices from 2009 (Gobierno de España, 2009). It benefited households with a contracted power lower than 3 kW, households consisting of retired people who were over 60 years of age, and large families or households in which all members were unemployed. The new law 24/2013 (Gobierno de España, 2013a), derived from Directive 2009/72/CE, has recognized the existence of a vulnerable consumer, which is defined just as in the previous law, but with a family income threshold limit that at the time of this writing is yet to be defined.

Later on, the European Commission, aware of the increasing number of fuel-poor households within the EU, stated that the pace of energy retrofits for dwellings should be accelerated. It was also stated that member states should invest money from Structural Funds and Cohesion Funds in energy-efficiency measures to fight fuel poverty (European Parliament, 2012). All this creates an urgent need for member states to develop their own methods to appraise fuel poverty, as expressed by the European Economic and Social Committee (2013).

In Spain, the ‘State Plan for Promotion of Rented Housing, Building Rehabilitation and Urban Renewal and Regeneration 2013–2016’ (Gobierno de España, 2013c) provides the programme for building retrofits. Public encouragement of energy retrofitting is structured through subsidies and loans directed at reducing the energy demand by at least the 30% through the improvement of thermal enclosure and facilities of dwellings. The housing stock that is eligible for this aid is limited to buildings constructed before 1981, when the first Spanish thermal performance regulation was launched. Within the framework of this plan, ‘Law 8/2013 of Urban Rehabilitation, Regeneration and Renovation’ (Gobierno de España, 2013b) is developed. For the first time, fuel poverty is mentioned in one of the objectives of a law: ‘to fight against fuel poverty through efficiency and energy saving actions’. However, it does not offer any definition or specific actions related to fuel poverty. In addition, the Spanish Technical Code (Ministerio de Fomento, 2013), which contains the required thermal conditions for energy efficiency, has highlighted the need for more knowledge about fuel poverty.
of buildings, has been modified as a result of this law and now any retrofitting work must accomplish minimum thermal requirements.

Apart from the above, there are some energy policies that are connected to the fuel poverty issue as they aim at the reduction of building energy consumption. Royal Decree 235/2013 (Gobierno de España, 2013d), which is derived from Directive 2010/31/UE (European Parliament, 2010), established a mandatory building energy performance certification for buildings for rent or sale. It also established that all new buildings must be nearly zero-energy buildings (NZEB) from 2020 onwards. These certifications must include possible energy improvements with a cost–benefit evaluation.

In addition, the Energy Saving and Efficiency Plan 2011–2020 (Ministerio de Industria Turismo y Comercio, 2011), based on Directive 2006/32/EU (European Parliament, 2006) and later on 2012/27/EU (European Parliament, 2012), established a mandatory building energy performance certification for buildings from 2020 onwards. These certifications must include possible energy improvements with a cost–benefit evaluation.

On the other hand, the income and expenditure approach was developed by using the Spanish Family Budget Income survey, EPF (Instituto Nacional de Estadística, 2004). The EPF was explored in order to obtain data on household incomes, derived from net monthly income per household, and expenditure on energy bills, constructed using bills for electricity, gas and other fuels used in primary and holiday homes. Despite the fact that this is a national survey and the best data source in order to appraise households’ energy consumption, it contains real expenditure, not estimated, which is one of its limitations. The sample size of this survey is 1820 households for the Autonomous Region of Madrid. In this case spatial raising factors, provided by National Statistics Institute for each household, were used too in order to raise sample data to the whole population (Instituto Nacional de Estadística, 2010).

Once the overall framework for fuel poverty was analysed, the income expenditure approach was chosen for the rest of the study, aimed at ascertaining the relationship between fuel and monetary poverty as well as characterizing the stock of dwellings where these different population groups live. Thus, one of the main reasons for the choice of this method was that the EPF gathers not only data on income and expenditure, which facilitates the analysis of monetary and fuel poverty, but also broader data on main housing conditions than the EU-SILC ones. Furthermore, despite the limitations detected in EPF data which are based on real expenditure (instead of a modelled one), it contains information related to high temperatures (cooling expenditure) unlike the EU-SILC survey.

Another survey, explored to expand on some information, was the Households and Environment Survey (Hogares y Medio Ambiente, HYMA) (Instituto Nacional de Estadística, 2008), a national survey that contains information related to household habits, consumption patterns and attitudes towards environmental issues.

**Material and methods**

**Measuring fuel poverty through statistical data**

The Autonomous Region of Madrid was chosen as a suitable case study for this research due to statistical reasons. The official national statistics are broken down by region. Madrid is one of the Autonomous Regions with the highest population concentrated in a region with the same weather conditions, which makes household energy needs comparable.

The first step of the study consisted of exploring the incidence of fuel poverty within the Autonomous Region of Madrid and determining the most suitable method to achieve the objectives of the study. For that purpose both the main accepted methods explained in the previous section, the consensual approach and the income and expenditure one, were taken into account.

The consensual approach was explored through the EU-SILC survey (Instituto Nacional de Estadística, 2006), as it contains breakdown data by regions. From this survey three indicators were evaluated: ability to pay to keep the home adequately warm; arrears in utility bills; and the presence of leaking roofs, damp walls or rotten window frames. The sample size of this survey is 1536 households for the Autonomous Region of Madrid. Spatial raising factors provided by the National Statistics Institute for each sample household were used to raise sample data to the whole population of the region (Instituto Nacional de Estadística, 2013).

Once the overall framework for fuel poverty was analysed, the income expenditure approach was chosen for the rest of the study, aimed at ascertaining the relationship between fuel and monetary poverty as well as characterizing the stock of dwellings where these different population groups live. Thus, one of the main reasons for the choice of this method was that the EPF gathers not only data on income and expenditure, which facilitates the analysis of monetary and fuel poverty, but also broader data on main housing conditions than the EU-SILC ones. Furthermore, despite the limitations detected in EPF data which are based on real expenditure (instead of a modelled one), it contains information related to high temperatures (cooling expenditure) unlike the EU-SILC survey.

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**Household classification: income and energy bills’ expenditure**

Once the general frame for fuel poverty was established, the relationship between fuel and monetary poverty was developed on the basis of statistical data from the EPF of 2011. To that end, households were
classified according to their relative position regarding monetary and fuel poverty thresholds.

The monetary poverty threshold was calculated as 60% of the median income value, following the EUROSTAT method. To this end, income was equivalized by taking into account household consumption units, using the modified Organisation for Economic Co-operation and Development (OECD) scale (1.0 for the first adult, 0.7 for the second and each subsequent person aged 14 and over, and 0.5 each child under 14).

The fuel poverty threshold was established as an expenditure of the 10% of income on energy, in line with existing fuel poverty research in Spain (Tirado Herrero et al., 2012). Given that income was equivalized through OECD-modified equivalizing factors, and that the same factors are commonly used for expenditure equivalization (Instituto Nacional de Estadística, 2012), these same factors were used for energy expenditure. Thus, fuel poverty ratio (FPR) was calculated as follows:

\[ \text{FPR} = \frac{\text{equivalised real fuel costs}}{\text{equivalised income}} \]

In addition, vulnerability towards each type of poverty was considered and, hence, thresholds of median income and 5% of expenditure were also considered.

Thus, households were gathered into six different groups according to previously defined thresholds.

Characterization of the housing stock
The relation between the six household groups and their housing stock characteristics was established.

Results
Incidence of fuel poverty
The overall incidence of fuel poverty in the Autonomous Region of Madrid was explored through both established methods, the income and expenditure approach and the consensual one, as explained above.

The income and expenditure method was developed by calculating the percentage of households that spend more than a certain percentage of their income on energy bills. Figure 1 shows the evolution of household expenditure from 2006 to 2011. The fuel poverty threshold, the expenditure of more of the 10% of household income, is plotted as well as 5%, 15% and 20% in order to give a broader vision of the problem. According to this method, 13% of households were suffering from fuel poverty in 2011, twice
the percentage of the fuel-poor households existing in 2008. Besides that, there is a general increase in household expenditure percentage, which reflects a rise in the effort needed by households to pay for their energy requirements and thus in the number of fuel-poor households too.

On the other hand, the consensual approach was explored through three indicators from the EU-SILC: ability to pay to keep the home adequately warm; arrears in utility bills; and the presence of leaking roofs, rising damp or rotten window frames. Figure 2 shows the percentage of households who declared themselves to be suffering from any of these problems from 2006 to 2011 along with the winter degree-days for this period. It can be seen there is a relation between winter conditions and the presence of leaking roofs, rising damp or rotten window frames, but not...
with the other two variables: the ability to pay to keep the home adequately warm and arrears in utility bills.

The upward trend in arrears seems to be related to a rise on energy prices as shown in Figure 3, while the ability to afford warmth seems to remain independent, perhaps due to its subjective nature. Furthermore, the increase in energy prices seems to be also related to an increase in the percentage of income that families have to spend on energy bills, as reflected in Figure 1.

After exploring both fuel poverty methods, some limitations were detected in the implementation for the Autonomous Region of Madrid. Firstly, the income and expenditure approach, carried out through data from the EPF, only reflects households’ actual expenditure, not their real needs. Secondly, the consensual approach is based on indicators derived from the EU-SILC that are mainly focused on winter necessities, which underrates Madrid’s extreme summer temperatures and related cooling needs, reflected in a presence of air-conditioning devices in the 43.5% of households (HYMA).

Nevertheless, the income and expenditure approach was considered the most suitable method for the rest of the study given that it reflects all households’ energy service expenditure, which includes both heating and cooling. It was also chosen because it contains data from housing stock characteristics.

Monetary and fuel poverty overlap in households
Given the overall incidence of fuel poverty, households were divided into groups in order to understand more deeply the relation between fuel and monetary poverty. For that purpose, EPF data from 2011 were explored. Figure 4 shows households plotted according to income level (y-axis) and energy bills’ expenditure (x-axis). Along with households some relevant reference thresholds were plotted as well to enable household division following the next steps:

- First, the monetary poverty threshold was established and, consequently, households were divided into two groups: poor ones and not poor ones.
- Second, the fuel poverty threshold, established as an expenditure of more than the 10% of income on energy, was used to divide households into four groups: the fuel and monetary poor ones; the monetary poor ones; the fuel-poor ones; and the not poor ones. In addition, the 20% threshold was plotted in order to understand the representativeness of the sample of households in a ‘severe fuel poverty’ situation.
- Third, the group of households not suffering from any kind of poverty was considered to be not homogeneous. This allowed for the existing

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Figure 5  Households division into groups according to fuel and monetary poverty thresholds
differences among households’ relative distances to previously established poverty thresholds to be taken into account. Some households were closer to these thresholds than the others and, therefore, were considered to be in a more vulnerable situation. For that reason this group was divided by using the median income, reflecting a monetary vulnerability situation. In addition, within this monetary vulnerability group the 5% of expenditure threshold was utilized to subdivide it on the basis of their vulnerability towards fuel poverty.

The division of households created six household groups, as it can be seen in Figure 5. The following is a more detailed explanation of these groups:

- **Group 1**: below both the monetary and the fuel poverty line. Households in this group fall within both poverty types (energy expenditure and income levels).
- **Group 2**: below the monetary poverty line but above the fuel poverty line. This group consists of households whose income is less than 60% of median income.
- **Group 3**: below the fuel poverty threshold but above the monetary line. Formed by households whose expenditure on energy bills is above 10% of their income but whose income is more than 60% of median income.
- **Group 4**: monetary and fuel poverty vulnerability: households whose income level is above the monetary poverty line but under the median income level, and whose energy expenditure is between 5% and 10% of their income. These households were considered vulnerable because an increase in their expenditure or a decrease in their income would place them below one of the two poverty lines.
- **Group 5**: monetary vulnerability: these households’ income is more than 60% of median income but below the median income line, and their energy expenditure is less than 5% of their income. These

Table 1. Household classification according to income and expenditure

| Group | Criteria                        | Number of households |
|-------|--------------------------------|----------------------|
| 1     | Monetary and fuel poverty       | 164 445              |
| 2     | Monetary poverty                | 266 085              |
| 3     | Fuel poverty                    | 144 819              |
| 4     | Monetary and fuel vulnerability | 280 101              |
| 5     | Monetary vulnerability          | 326 845              |
| 6     | Not vulnerable                  | 1 181 778            |

Figure 6. Household distribution according to income and expenditure

Figure 7. Housing stock qualitative variables: dwelling type, year of construction and heating availability
households could be considered vulnerable from a strictly monetary point of view.

- Group 6: not vulnerable: this group is stable in terms of both monetary and energy expenditure, and distanced from vulnerable positions.

Based on the results displayed in Table 1 and Figure 6, it can be stated that 24% of Madrid’s households suffer from some kind of poverty. According to this classification, the 18% of households suffer from monetary poverty (Groups 1 and 2) and almost the 40% of them can be considered fuel poor. Households above the monetary poverty threshold that suffer from fuel poverty form the 6% of the total. Finally, total fuel-poor households make up the 13% of all households.

Exploring the relation between key factors

Once households were divided into six different groups according to their position regarding income and energy expenditure, their housing stock was characterized in order to understand the relation between fuel poverty, monetary poverty and their shelter, given that this is the third factor in the equation of fuel poverty.

First, the qualitative variables are taken into account: dwelling type, year of construction and heating availability (Figure 7).

The analysis of the dwelling type was conducted by dividing the sample according to the variables: building block and detached or semidetached house. Results show that the 88% of households in the Autonomous Region of Madrid are located in apartment blocks. Nevertheless, this percentage is higher among groups identified as vulnerable or in a situation of any kind of poverty.

The year of construction was considered an important variable as it reflects the thermal efficiency of dwellings. The first building efficiency regulations in Spain were released in 1979 (Gobierno de España, 1979). This means that the majority of dwellings that are more than 25 years old were built without any efficiency regulations. More than 80% of households in Groups 2 and 5 are located in old dwellings while Groups 3 and 6 live in the newest housing stock.

In addition, the results show that roughly 91% of households have some type of heating system, but the distribution of heating availability is not uniform amongst all household groups. Almost 33% of Group 2 has no heating system, which represents the 43% of all households without this facility.

Some quantitative variables considered relevant to energy consumption in dwellings, as dwelling living areas and the corresponding area per household member were also studied.

The living area per household revealed some differences among groups as well, despite the fact the median of all groups varies between 70 and 90 m², as shown in Figure 8. Households in Groups 2 and 5 live in the smallest houses while Groups 3 and 6 enjoy the largest areas.
Figure 9 shows the analysis of the number of members. As it can be seen, Groups 1, 3 and 4 are mainly formed by one or two people, while Groups 2, 5 and 6 contain bigger families with a median number of three members. The largest families can be found in Group 2. The living area per household member was then appraised and plotted in Figure 9. Members from Groups 2 and 5 live in the smallest areas with a median of 22 and 28 m² per household member respectively. By contrast, Group 3 members live in the biggest area with a remarkable difference with respect to the rest of the groups (40 m² per household member).

Discussion

The evaluation of the incidence of fuel poverty by means of two methods shows different perspectives on the problem, although both highlight a rising incidence of fuel poverty. The self-reported method shows an increase in family arrears, while the income and expenditure approach reveals a rise in the percentage of the household budget spent on energy bills in recent years. The results of the analysis show that fuel poverty is a real and growing problem in this region. However, the availability of data related to real expenditure instead of modelled expenditure underestimates the number of households needing to spend more to obtain adequate temperatures.

The method implemented in this study would be suitable for any other region if survey data are available.

The present research provides a broader vision of the position of households with respect to monetary and fuel poverty thresholds. This permits the measurement of the incidence and the overlap of both types of poverty. The classification of households into six groups makes possible the distinction between them on the basis of their degree of vulnerability and/or the assistance they may require. A first approach, derived from this classification, demonstrated that Group 6 could be classified as being in the best position, whereas Group 1 as the most in need.

In addition, the analysis of the housing stock characteristics brings in the third factor of fuel poverty providing a deeper insight on the complexity of households’ vulnerability. Two groups stand out from the others (Groups 2 and 3) due to their extreme distinctive values in building age, heating availability and living area per household member. The characteristics of their dwellings make these groups representatives of what could be considered the two faces of fuel poverty: excessive energy expenditure and inadequate indoor temperatures.

Group 2 is formed by poor households, below the monetary poverty threshold, with low energy expenditure. The housing stock is the oldest of all groups, with the 83% of its housing built before the first Spanish efficiency regulations, therefore it is presumed to be energy inefficient. Furthermore, the 43% of all households with no heating system are concentrated in this group. Taking into account that Madrid has 2440 annual heating degree-days and 374 annual cooling degree-days (Instituto para la Diversificación y Ahorro de la Energía, 2010) it is reasonable to suggest that these families do not experience adequate household temperatures which poses important health risks for these families (Díaz et al., 2003; Simón, López-Abente, Ballester, & Martínez, 2005). Hence, this group can be considered as fuel poor, through this deeper analysis is in contrast to the first approach described above. Although living in dwellings with a median area similar to the other groups, the resulting median area per member is one of the smallest amongst all groups at 22 m² per member.

Group 3 consists of households located above the monetary poverty line but which suffer from fuel poverty, conceived as an excessive expenditure on energy bills according to the income and expenditure method. They live in the newest housing stock of all vulnerable-considered groups; more than the 40% of these dwellings were built after first Spanish energy efficiency regulations were implemented. This group holds the highest rate of heating availability of all groups. The fact that its occupants enjoy the biggest area per household member among all groups may explain their high expenditure on energy bills.

Group 1 has the deepest vulnerability due to the overlap of both monetary and fuel poverty. Its housing conditions show a mixture of variables that confirm the weakness of this group. Households in Group 1 live in dwellings that were mainly built before first energy efficiency regulations (Gobierno de España, 1979) thus they are expected to have a poor thermal performance. In addition, the area per household member is bigger than Group 2, which increases Group 1’s energy needs. When combined with a high heating availability (almost the 84% of dwellings), this places the group to be above the 10% expenditure threshold.

Groups 4 and 5, initially classified as vulnerable but not below any poverty threshold, show little difference in their housing stock. Nonetheless, their dwellings, chiefly old, are not efficient enough to keep them out of fuel poverty. The current rising energy prices and
decreasing salaries (due to present economic circumstances) make these groups more likely to fall into fuel poverty in forthcoming years than Group 6. This last group is formed by households that have no income shortfall and that are also located above the fuel poverty line.

**Conclusions**

The results of the research have shown the existing relationship between fuel and monetary poverty, in line with recent reports (Atanasiu, Kontonasioù, & Mariottin, 2014). In the Region of Madrid, almost the 24% of the households suffer from some kind of fuel poverty (either due to the high percentage of their incomes expended in energy bills or because of the inability to afford adequate warmth at home). As found in the study of the six population groups identified, fuel poverty is a complex issue that can emerge in different ways and from diverse household situations. In order to face this problem there are three urgent needs:

- To establish an official definition of the term ‘fuel poverty’ that gathers all its complexity. To this end, some groups from the Spanish Parliament (Grupo Parlamentario de la Izquierda Plural, 2013) presented a legislative proposal claiming for the recognition of the problem and the creation of a national plan against fuel poverty. Nonetheless, it was rejected and there is still a need for this specific, official and targeted definition.

- To develop more robust statistical data that allow a deeper knowledge of the problem. To date, general evaluation and comparison amongst European countries has been made through the exploitation of the EU-SILC data. However, as shown in this research, it does not provide accuracy for lower scale studies. Furthermore, it includes neither cooling needs nor the high temperatures registered within these dwellings, which represent an important health risk in south European countries (Robine et al., 2008). The EPF data relative to actual expenditure of households make it difficult to detect those families who cannot afford their energy bills and, consequently, have low energy expenditure. Efforts should be made to improve the understanding of housing energy performance in order to estimate properly the expenditure required by households.

- To implement specific policies aimed at households detected as primary targets in this characterization. Although some existing policies are now being used to tackle fuel poverty, the present study reveals shortfalls that need to be addressed. The social energy tariff (Gobierno de España, 2009) is aimed at alleviating energy bill expenditure, but it cannot provide a long-term solution to fuel poverty. This is due to the current constant increase of energy prices, shown in Figures 1 and 3. Furthermore, as pointed out by the Buildings Performance Institute Europe (Atanasiu et al., 2014), these measures do not generate added value or economic growth in the country.

By contrast, taking into account the antiquity of the housing stock of the vulnerable population, energy retrofitting can be considered as the most suitable measure to provide a stable and long-term solution to fuel poverty. In fact, energy-efficiency measures specifically launched for low-income households have proved to be successful practices in countries with an extended experience on tackling fuel poverty (Hamilton et al., 2014). These measures demonstrated the positive impacts on the reduction of household energy expenditure and on occupants’ health by improving indoor temperatures. Nonetheless, Spanish retrofitting policies are not focused enough on the eradication of fuel poverty. This is the case of the ‘State Plan for Promotion of Rented Housing, Building Rehabilitation and Urban Renewal and Regeneration 2013–2016’ (Gobierno de España, 2013c). In this plan the low-income households are taken into account in order to prioritize the interventions, but they are not its main target. Aid is targeted at dwellings built before 1981 and, as detected in Group 3, there are fuel-poor families living in dwellings built after that year with excessively high energy bills. Thus, this regulation would not respond to this population needs and would be leaving behind important opportunities of energy saving. Furthermore, subsidies cover up to the 35% of the intervention costs, which make the refurbishment likely to be unaffordable for the lowest income households, Groups 1 and 2. Financial aid derived from PAREER Scheme (Gobierno de España, 2013e, 2013f) poses similar barriers since a guarantor of the 20% of the total costs of the refurbishing costs is required. In addition, all mentioned policies should clearly stimulate the implementation of passive strategies in order to improve indoor thermal conditions in these households. Finally, the recent improvements in energy certification of buildings (Gobierno de España, 2013d) can provide a positive boost for energy retrofits of dwellings. Nonetheless, energy performance certification may become create a revenge effect for low-income families. Energy labelling could raise the prices of the most efficient houses, which would displace the low-income population to those houses with the lowest energy rating.

Fuel poverty has an important and increasing presence in the Region of Madrid given that current policies do not guarantee the accomplishment of minimum requirements. Specific policies are needed so that fuel poverty can be eradicated in all Spanish territory.
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