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Quantifying the prevalence of fuel poverty across the European Union

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HIGHLIGHTS

- ► This research is the first comparative analysis of European fuel poverty since 2004.
- ► Fuel poverty is a particular problem for eastern and southern European member states.
- ► Recommendations include the improved integration with current EU climate policies.

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ABSTRACT

The literature and policy base for fuel poverty in the UK and Ireland is well established, and there is a growing body of single country studies beyond these two EU member states (for example Brunner et al. (2012), Dubois (2012), and Tirado Herrero and Ürge-Vorsatz (2010)), however, on a European level, the last analysis of fuel poverty was conducted in 2004, prior to the enlargement of the EU. Using survey data this paper presents an updated overview of the prevalence of European fuel poverty in the context of the accession of numerous former social states, and rising fuel prices.

Analysis reveals the phenomenon of fuel poverty is occurring across the EU, with particularly high levels of fuel poverty found in Eastern and Southern European states. It is argued that there are both EU and national policy frameworks in place that address climate change and these could be used as a starting point for countries to address fuel poverty through improved domestic energy efficiency measures.

This paper reflects research undertaken in 2011, supported by eaga Charitable Trust, within the umbrella of work examining issues of poverty and social exclusion across the EU, which has enabled access to the EU-SILC dataset.

1. Introduction

Of the 27 EU member states, only three have an official definition of fuel poverty (the United Kingdom, Republic of Ireland and France), and national levels of awareness regarding fuel poverty are varied. Yet, the drive towards a single liberalised energy market, the accession of numerous former socialist countries and the subsequent removal of subsidised energy tariffs, means it is increasingly likely that fuel poverty is a European-wide phenomenon (European Economic and Social Committee, 2011). However, there is a distinct gap in knowledge regarding the extent of fuel poverty on a European scale, which this paper will begin to address, using standardised EU Statistics on Income and Living Conditions (EU-SILC) data.

Over the last decade the EU has taken a prominent role in promoting energy security, climate change mitigation and sustainable development. Policy has been implemented in a range of areas, from the European Council Directive (2009a) on common rules for the internal market in electricity, which requires Member States to undergo electricity market liberalisation, the European Council Directive (2003) establishing a scheme for greenhouse gas emission trading for energy intensive industry, to the Europe 2020 strategy, which amongst other objectives, aims to reduce greenhouse gas emissions by 20 per cent, increase the share of renewable energy in the energy mix to 20 per cent and achieve a 20 per cent increase in energy efficiency by the year 2020 (European Commission, 2010a). By contrast, policy specifically addressing fuel poverty has been limited, despite the potential tension between climate change and fuel poverty policy objectives. This is also despite existing literature (see for example Fitzpatrick and Cahill (2002), Fitzpatrick (2011)) that suggests that in order to reconcile and achieve the policy goals of reduced fuel poverty and carbon emissions their interaction must be recognised. Policies that fail to do this may have the unintended

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consequence of increased levels of fuel poverty or carbon emissions—for example, climate policies that increase household energy bills are often found to be regressive if they do not protect poorest customers, conversely, fuel poverty policies that simply remunerate customers may lead to an increase in carbon emissions (see Tol (2007), Wier et al. (2005), Gough et al. (2008), Ürge-Vorsatz and Tirado Herrero (In press)).

Certainly, there have been discussions on fuel poverty, particularly with regard to social exclusion, with the European Commission stating "fuel poverty, which risks depriving households not only from heating or cooling but also from hot water, lights and other essential domestic necessities, is another manifestation of severe deprivation" (European Commission, 2010b). The same communication on poverty and social exclusion, later states: "energy policy will continue to contribute to address the consumer needs and, where appropriate, address the risks of energy poverty" (European Commission, 2010b).

To date, policy has been piecemeal, with no specific policy package addressing fuel poverty. European Council Directive (2009a,b) both acknowledge fuel poverty exists and require affected Member States to develop action plans, however, as Bouzarovski et al. (2012, p. 3) state, the EU has "stopped short of providing a common definition of the problem, which might give it better visibility at the member-state level", and likewise, no criteria for an 'affected Member State' is given. Similarly, in these directives, Member States are required to define a vulnerable customer possibly in relation to fuel poverty, but no guidance is provided on who is likely to be a vulnerable customer.

Fuel poverty is likely to be an increasing issue on a European level, and as such, this paper fills a significant gap in knowledge. In the following section, the causes, consequences and extent of fuel poverty will be discussed, with particular reference to the limitations of the existing literature on European-wide fuel poverty.

2. Background

2.1. Use of terms

Before addressing the causes of fuel poverty, the use of terms requires some discussion. At the EU level, there is a conflicting use of the terms energy poverty and fuel poverty. This exists even within EU institutions such as the European Commission, with both terms used in a communication concerning social exclusion (European Commission, 2010b). It has previously been stated that fuel poverty is a narrow measure (Ürge-Vorsatz and Tirado Herrero, In press) however this assertion was based on a misunderstanding of fuel poverty measurement in the UK; in addition to space heating needs, water heating, lighting and energy for appliances and cooking are also taken into account (Department of Energy and Climate Change, 2012) when considering the level of spending required on fuel in order to achieve a basic standard of living.

Given that fuel poverty is considered the most commonly accepted term throughout the industrialised world (Liddell et al., 2012), this paper will make reference to the term fuel poverty when describing the phenomenon whereby a household struggles to afford adequate services.

2.2. Defining fuel poverty

The main driver of fuel poverty is a "complex interaction between low income and domestic energy efficiency" (Healy and Clinch, 2002, p. 4), in addition to other contributory factors such as "the absence of savings and living in rented accommodation, both of which limit an occupant's opportunities to improve the property" (Boardman, 2010a, p. 21). The drivers of fuel poverty are likely to be similar throughout the EU, although, variation in the severity of each driver may exist between member states, for example in south-eastern Europe, the legacy of communism creates specific drivers of fuel poverty (Bouzarovski et al., 2012).

As highlighted above only three of the 27 EU member states have an official definition of fuel poverty, despite increasing concerns about its prevalence. The three definitions that do exist reflect the relationship between energy efficiency and low income.

The Irish government defines fuel poverty as "the inability to afford adequate warmth in a home, or the inability to achieve adequate warmth because of the energy inefficiency of the home" (Office for Social Inclusion, 2007, p. 67), whilst in France a person is considered fuel poor "if he/she encounters particular difficulties in his/her accommodation in terms of energy supply related to the satisfaction of elementary needs, this being due to the inadequacy of financial resources or housing conditions" (Plan Bâtiment Grenelle, 2009, p. 16). Finally, in the United Kingdom, a fuel poor household is: "one that cannot afford to keep adequately warm at reasonable cost. The most widely accepted definition of a fuel poor household is one which needs to spend more than 10% of its income on all fuel use and to heat its home to an adequate standard of warmth." (Department of Trade and Industry (DTI), 2001, p. 6)

There is much discussion on how to define and identify fuel poverty, with commentators generally favouring either an expenditure approach that uses actual or required fuel spend, or a consensual approach that utilises subjective indicators. There are numerous criticisms levied at the expenditure approach, as currently used by the United Kingdom, including its inability to "capture the deprivation and social-exclusion elements of fuel poverty" (Healy and Clinch, 2002, p. 9). There are also issues raised concerning the use of actual or required fuel spend; actual fuel spend is said to be a poor indicator of fuel poverty as households often spend less on fuel than is required (see for example Moore (In press) or Liddell et al. (2011)), whilst a measurement based on required fuel spend necessitates national housing condition surveys from which to calculate accurate required fuel spend (Moore, In press).

Due to the limitations of an expenditure approach, some authors advocate a consensual fuel poverty measurement grounded in the consensual poverty approach pioneered by Gordon et al., based on the inability "to afford items that the majority of the general public considered to be basic necessities of life" (Gordon et al., 2000, p. 7). Healy and Clinch's work at the EU level (Healy and Clinch, 2002) used a consensual approach to fuel poverty by analysing subjective and objective data on the presence of mould, the absence of central heating, and ability to keep warm. This approach is not without its flaws, including the likelihood of error of exclusion, with households not identifying themselves as fuel poor (Dubois, 2012). However, the use of a consensual measure of fuel poverty enabled Healy and Clinch to produce the first estimate of fuel poverty across the EU14 as standardised European data concerning household fuel spend was (and still remains) unavailable. Arguably, this is the key advantage of a consensual fuel poverty measure, particularly for cross-comparative research.

2.3. Consequences of fuel poverty

Although it has been found fuel poverty is not synonymous with general poverty (Hills, 2012), the two do certainly exacerbate each other; a low household income can cause households to restrict their use of appliances and heating and/or for debts to accrue, whilst high fuel costs, perhaps resulting from an energy inefficient property, can put pressure on household budgets, leading to households forgoing essential items, such as food. The lowering of living standards, often below what is considered 'acceptable', is a necessary action for many fuel poor households (see Brunner et al., 2012).

The health consequences of belonging to a fuel poor household are wide ranging, from an increased likelihood of suffering from illnesses such as "influenza, heart disease, and strokes" (Department of Trade and Industry (DTI), 2001, p. 7), to an increased risk of suffering from asthma due to the growth of fungi and dust mites that cold homes promote (Department of Trade and Industry (DTI), 2001, p. 8). There is also an increased likelihood of the use of health services by people living in cold homes; Evans et al. found "those who had difficulty keeping their home warm enough "most of the time" were nearly twice as likely to visit the surgery four or more times, and twice as likely to use outpatient departments as those who never experienced this problem" (Evans et al., 2000, p. 678), whilst a study of the impact of fuel poverty on children found that "for infants, living in fuel poor homes is associated with a 30% greater risk of admission to hospital or primary care facilities" (Liddell, 2008, p. 2).

Fuel poverty can also affect mental wellbeing and social contact, as well as the development of children. Harrington et al. (2005, p. 266) in their qualitative study of understanding and coping with fuel poverty found that respondents "identified the damaging psychosocial consequences of living in a cold home, including depression, social isolation and constraints on mobility". Whilst children in fuel poor homes have been found to have "poorer weight gain and lower levels of adequate nutritional intake…a "heat-or-eat" effect" (Liddell, 2008, p. 2).

However, the most extreme consequence of fuel poverty is the phenomenon of excess winter mortality (EWM), which is defined as "the surplus number of deaths occurring during the winter season (from December to March inclusive) compared with the average of the non-winter seasons" (Healy, 2003, p. 785). EWM is a phenomenon found across the EU; in his study of EWM across EU-14 from 1988 to 1997, Healy found Portugal and Spain suffered from the highest levels of EWM (2003b, p. 784), which challenges the perception that southern European countries are not affected by EWM, and indeed fuel poverty, due to their milder climates. Healy attributes the high levels of EWM to poor thermal efficiency standards, and suggests an improvement in standards could reduce the levels of excess deaths (Healy, 2003). More recently, researchers have explored summer mortality levels, with one study finding there were 70,000 additional deaths across 14 European countries during the heat wave of 2003 (Robine et al. 2008). In addition to this the authors suggest that climate change poses a new health threat to Europe (ibid.). Adaptation of buildings is therefore key to reducing the levels of mortality resulting from cold winter temperatures and hot summer temperatures, and energy efficiency measures may be able to address both issues, with Porritt et al. (2011) finding that external wall insulation was the most effective single intervention for heat wave periods (Porritt et al., 2011).

2.4. The extent of fuel poverty in the EU

As a result of increasing concerns about fuel poverty at the EU level, the European Fuel Poverty and Energy Efficiency (EPEE) project was commissioned in order to assess fuel poverty policy across five member states. The project ran from 2006 to 2009, and found that the level of recognition of fuel poverty, and consequently the level of policy interventions, varied considerably across the United Kingdom, Spain, Italy, Belgium and France. The EPEE project estimated fuel poverty rates across Europe to be "between 50 million and 125 million people" (EPEE, 2009, p. 4). The United Kingdom was found to have the greatest level of knowledge and understanding of fuel poverty, whilst in Spain "fuel poverty is not recognised at any significant level…there is no perception of fuel poverty as a compelling social problem" (EPEE, 2009, p. 7) despite evidence that indicates that southern European countries suffer from the highest levels of fuel poverty in Europe (Healy, 2004).

Aside from the EPEE project, and, as described above, several single country studies, the European fuel poverty literature base is severely limited, with only two published comparative studies. This lack of literature may be due to the limitations of currently available European data; as Healy and Clinch (2002, p. 9) assert, expenditure based definitions of fuel poverty cannot be used for cross-country analysis as "data on fuel expenditure as a proportion of household income on a micro level is not available in many European countries", which necessitates alternative measures of fuel poverty, such as using a consensual measure.

The first of the two comparative studies was undertaken by Whyley and Callender (1997) who conducted a cross-national comparison using European Community Household Panel (ECHP) data, comparing the United Kingdom, Ireland, the Netherlands and Germany (Whyley and Callender, 1997, p. i). The second major study was conducted by Healy and Clinch (2002) who calculated the extent of fuel poverty in fourteen European countries using ECHP data from 1994 to 1997, with both pieces of research reporting similar findings. Healy and Clinch found that fuel poverty was the highest in Southern Europe; with Portugal, Greece, Spain and Italy demonstrating the highest levels (Healy and Clinch, 2002, p. 33). In Northern Europe, the rates of fuel poverty were lower, but France, Belgium, the United Kingdom and Ireland exhibited relatively high incidences (Healy and Clinch, 2002, p. 34).

However, this existing evidence base is limited since the EU has enlarged noticeably since 1997. It is argued that this will cause fuel poverty to become a more significant concern at the EU level as the removal of subsidies amongst many Former Soviet Union countries and satellite states and a move towards a competitive energy supply has meant that "most governments have been unable to develop the necessary social safety nets to protect vulnerable households from energy price increases" (Buzar, 2007, p. 1). As such, there is a significant gap in knowledge and a need for further research into fuel poverty at the EU level. Using 2007 EU-SILC data from EU member states, this paper attempts to fill this gap in knowledge by addressing two key research questions, firstly, what levels of fuel poverty exist across the EU? And secondly, what increases a household's propensity to experience fuel poverty?

3. Methodology

As outlined in the previous section, this paper aims to investigate the levels of fuel poverty across the EU, and the factors that increase a household's propensity to experience fuel poverty. Using a consensual approach, which aims to capture a broad picture of fuel poverty, and circumvent issues around the absence of standardised European data concerning household fuel spend, an EU-wide comparative analysis of fuel poverty has been conducted using standardised EU-SILC data from 2007.

3.1. Proxy indicators of fuel poverty

Due to the lack of European micro data concerning household fuel expenditure (as discussed above), three proxy indicators have been selected to measure fuel poverty across the EU: ability to pay to keep the home adequately warm, arrears on utility bills, and the presence of a leaking roof, damp walls or rotten windows.

This selection mirrors previous research in the field, and as with Healy and Clinch's work (2002), the use of these three variables provides a consensual measurement of fuel poverty, which captures a broader picture of need than analysis of household fuel expenditure alone would provide. A combination of indicators has been used as fuel poverty is a complex phenomenon, with significant variations in the lived experience of fuel poverty. As outlined by the EPEE (2009, p. 4) project, "fuel-poor households will experience a number of symptoms or demonstrate certain characteristics", indicators of which may include "the inability to pay energy bills, cold damp living conditions…debt owed to the energy supplier" (EPEE, 2009, p. 4), and as such, the use of only one indicator would not provide an accurate portrayal of fuel poverty

3.2. Data

The EU-SILC aims to be a "reference source for comparative statistics on income distribution and social exclusion at European level" (Eurostat, 2010, p. 10), and it provides comparable annual data in two formats, cross-sectional and longitudinal. In this research, cross-sectional household data from the year 2007 is used, and the cumulative household sample size across all twenty seven countries for the survey year 2007 is 201,064; however Malta and France are missing from the 2007 data, and the variable ability to heat the home adequately was not included in the Danish survey, therefore the predicted levels of EU fuel poverty are likely to be underestimated. A household cross sectional weight has been applied to the data, which has resulted in the enlarged household sample distribution. The household cross sectional weight applies to all respondent households and enables an estimation of fuel poverty on a population scale.

Table 1 displays the variables used during analysis, and provides a short overview of why these variables have been included in the analysis. From these variables, the presence of a leaking roof, damp walls or rotten windows, the ability to pay to keep home adequately warm and arrears on utility bills have been chosen as proxy indicators of fuel poverty, as will be clarified in the following section.

3.3. Data weaknesses

The EU-SILC dataset is a significant improvement on its predecessor, the ECHP, which suffered from issues of reliability, varied response rates and incomplete geographical coverage (Clemenceau and Museux, 2007). However, several variable changes occurred during the transition from ECHP to EU-SILC which made it more difficult to model EU fuel poverty, including the loss of a variable asking if a dwelling had heating or electric storage heaters, and the merger of three separate housing condition variables (leaky roof, damp walls, floors foundations, and rot in window frames or floors) to form a single variable in EU-SILC.

Despite the improvements on the ECHP made with the launch of the EU-SILC, some data weaknesses remain, namely concerning the EU-SILC sampling procedure, with only people living in private households from fixed populations surveyed. People living in collective households and in institutions are usually excluded from the EU-SILC target population, which includes older people, people with disabilities and vulnerable groups such as the homeless (Clemenceau and Museux, 2007). In addition, by only surveying fixed populations, nomadic groups such as Roma populations are excluded from the sample. The European Bank for Reconstruction and Development found that within Bulgaria, "although only 9 per cent of the population is Roma, they represent 62 per cent of poor people" (European Bank for Reconstruction and Development, 2003,

Table 1
EU-SILC variables selected for analysis.

Variable Name	Measurement	Coding	Reason for inclusion
Ability to pay to keep home adequately warm	Self-reported	1=No 0=Yes	"Encompasses the standard definition of fuel-poor households" (Healy and Clinch, 2002, p. 12), and is therefore a key proxy for fuel poverty
Arrears on utility bills within last 12 months	Self-reported	1=Yes 0=No	Experiencing financial difficulties with utility bills may indicate a household is struggling to afford adequate services
Leaking roof, damp walls or rotten windows	Self-reported	1=Yes 0=No	The presence of a leaking roof, damp walls or rotten windows may indicate a property is being continuously unheated or ineffectively heated (Healy and Clinch, 2002), a possible consequence of fuel poverty
Degree of urbanisation	Constructed by Eurostat	Two dummy variables	The effects of residing in a thinly populated (rural) area ("belonging neither to a densely-populated nor to an intermediate area" Eurostat (2010), p. 106) and in an area of intermediate urbanisation (density of >100 inhabitants per square kilometre and total population of at least 50,000 inhabitants, Eurostat (2010)) are compared with households in a densely populated area (density of >500 inhabitants per square kilometre and total population of at least 50,000 inhabitants, Eurostat (2010)) to explore if a rural location is associated with worsened levels of fuel poverty, as found in the UK (Hills, 2012). In addition to this there are found to be higher levels of rural poverty in the former soviet countries, as Macours and Swinnen (2008, p. 2183 put it ' the share of rural poverty in total poverty will further increase in the future. This indicates that the focus on rural poverty will be essential for overall poverty reduction strategies'. This dimension was also used by Healy, 2004
Dwelling type	Self-reported	Two dummy variables	To explore differences between dwelling types as these are likely to vary in terms of their energy needs and efficiency (e.g. see Hong et al. (2006))
Tenure status	Self-reported	Three dummy variables	Living in rented accommodation limits opportunities to improve the property (Boardman, 2010a)
More than 3 rooms available to household	Constructed from number of rooms available	1=No 0=Yes	Closely related to dwelling type, to explore the relationship between property size and fuel poverty (see Hong et al. (2006))
Ability to make ends meet	Binary variable constructed from self-reported scale	1=Some difficulty 0=No difficulty	Provides a subjective assessment of a household's financial capability to make ends meet, which is important given the tensions between income and fuel poverty (Healy and Clinch, 2002)
Former socialist state	Constructed from country variable	1=Yes 0=No	Identifies if households reside in a Member State that was formerly under socialist influence. Authors such as Boardman (2010a) state that the addition of countries such as "*Bulgaria, Czech Republic, Hungary, Poland, Romania and Slovenia… [mean] the problem of fuel/energy poverty (they mean the same thing) has, at last become an EU concern*" (Boardman, 2010a, p. 15)

p. 70), and similarly, within Romania "poverty is also significantly greater in large families and in the Roma population" (European Bank for Reconstruction and Development, 2003, p. 151). The indications are that Roma populations consequently suffer from high levels of fuel poverty too, with research from Hungary stating, "severe cases of fuel poverty experienced by Roma families living in geographically remote rural areas where very few income earning opportunities exist have been identified" (Tirado Herrero and Ürge-Vorsatz, 2010, p. 28).

In addition to issues of sampling, some caution should be applied when reviewing the results as the arrears on utility bills variable refers to all household bills, including water, which may create an overestimation of fuel poverty based on this indicator alone. In addition, there are some anomalies with the data, for example, this variable shows the United Kingdom as not experiencing any arrears, which is incorrect based on Office of Gas and Electricity Markets reports of gas and electricity debt repayments (Ofgem, 2011).

4. Findings

4.1. Consensual measures of fuel poverty

As outlined previously, a consensual approach has been taken to measure fuel poverty across the EU, due to a lack of data concerning household fuel spend, and in order to capture a broad picture of fuel poverty. Three proxy measures of fuel poverty have been chosen, and in the findings section that follows a detailed summary of each indicator will be presented, followed by a composite measurement of fuel poverty across EU25, and multivariate logistic regression models to examine the factors that increase a household's propensity for experiencing fuel poverty.

4.1.1. Ability to keep home adequately warm

This proxy indicator asks "can your household afford to keep its home adequately warm?" (Eurostat, 2010, p. 176), which whilst being highly subjective, provides an insight into the perceived affordability of heating homes across the EU. Fig. 1 illustrates the percentage of households that declared they were unable to pay to keep their home adequately warm in the survey year 2007.

Whilst in all Member States the majority of households are able to heat their home adequately, there are clearly issues of affordability in some countries. The highest levels of inability to pay to keep the home warm are found in Portugal (35.3 per cent), Bulgaria (31.6 per cent) and Cyprus (30.8 per cent), with considerably higher levels than the EU average of 12.1 per cent. By comparison, Luxembourg, Estonia and Sweden have relatively low instances of an inability to pay to keep the home adequately

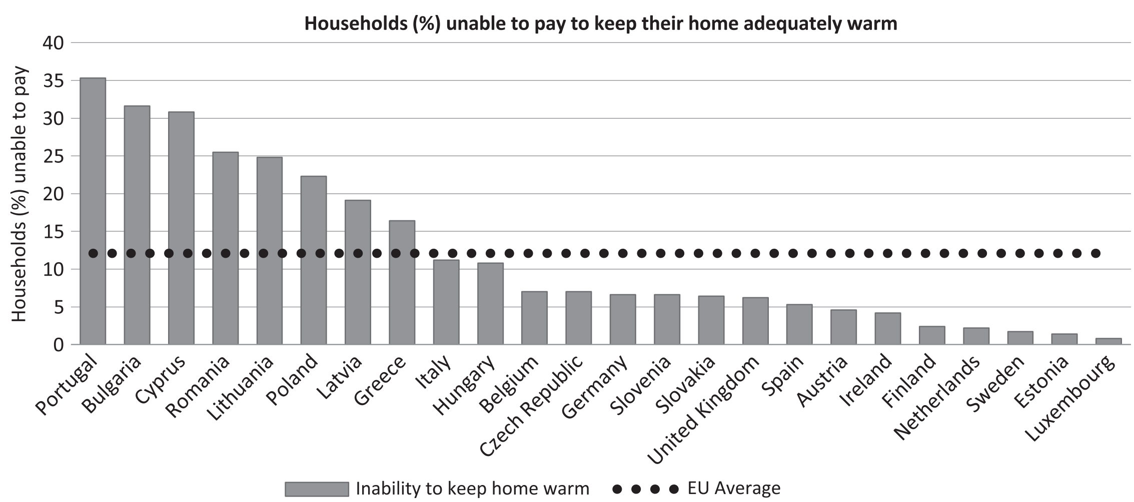

Fig. 1. Households unable to pay to keep their home adequately warm, χ^2 (23)=11,532,998.23, $p=<.001$.

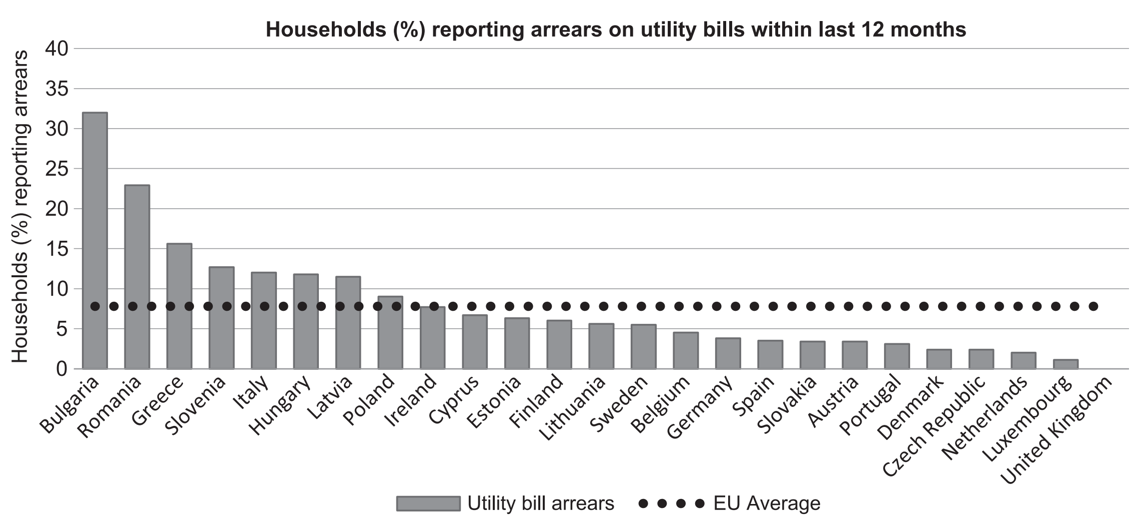

Fig. 2. Households in arrears on utility bills in the last 12 months by country, χ^2 (24)=11,145,161.94, $p=<.001$.

warm, with less than two per cent of households in each country stating they are unable to pay. Denmark is absent from the results as the ability to pay to keep the home adequately warm variable was not asked in the 2007 sample.

4.1.2. Arrears on utility bills in last twelve months

The arrears on utility bills variable has been included as a proxy indicator as experiencing financial difficulty with regard to gas and electricity costs potentially indicates a household has a low income, and subsequently are at risk of experiencing fuel poverty. As shown in Fig. 2, there are lower levels of declared arrears on utility bills than declared inability to heat the home adequately.

Less than two per cent of households in the Netherlands and Luxembourg reported arrears, whilst the United Kingdom does not report any instances of arrears on utility bills, although, as discussed previously, the United Kingdom does experience some level of arrears on utility bills. The highest levels of arrears were reported in Bulgaria (32 per cent), Romania (23 per cent) and in Greece (16 per cent), whilst the EU average for households reporting experiencing arrears on utility bills was just 7.8 per cent.

4.1.3. Leaking roof, damp walls/floors/foundation, or rot in window frames or floor

This proxy indicator provides "an objective measure of the condition of the dwelling" (Eurostat, 2010, p. 175), and as stated by Healy and Clinch, the presence of damp "indicates that the dwelling is not energy efficient. It may also be a manifestation of a continuously unheated or ineffectively heated home" (Healy and Clinch, 2002, p. 15), and is therefore an appropriate indicator of fuel poverty.

As can be seen in Fig. 3, high levels of households reporting the presence of a leaking roof, damp walls or rotten windows were found in most Member States, with an EU average of 18.1 per cent. Only four Member States had less than ten per cent of households reporting poor housing condition, Denmark (8.4 per cent), Finland (4.3 per cent), Sweden (7.4 per cent) and Slovakia (9.4 per cent). High levels of poor housing condition were found in Hungary (31.2 per cent), Slovenia (30.8 per cent), Bulgaria (29.1 per cent) and Cyprus (26.8 per cent).

4.2. Composite measurement of fuel poverty

As discussed above, fuel poverty is a complex phenomenon with multiple drivers; the advantage of a composite measure of fuel poverty is that it enables several complex indicators to be combined to produce a single figure. Replicating Healy and Clinch's (2002) aggregated measurement of fuel poverty, four estimates of fuel poverty levels across EU25 are presented below. However, due to the variable changes that occurred during the transition from the ECHP dataset to EU-SILC, only two scenarios are directly replicated from Healy and Clinch's work. Using the three proxy indicators outlined previously, four scenarios are presented in Table 2 in which each indicator is assigned a weight; the weight applied varies depending on the scenario. Using a

Table 2
Composite levels of fuel poverty across EU25 (% of households).

Country	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Austria	6.2	5.9	8.2	6.7
Belgium	9.2	8.5	11.9	9.8
Bulgaria	31.1	31.2	30.5	30.6
Cyprus	23.8	17.8	22.8	21.2
Czech Republic	7.5	6.4	9.2	7.6
Denmark	2.7	3.3	4.8	3.6
Estonia	6.8	8.1	11.0	8.5
Finland	3.8	4.7	4.3	4.2
Germany	7.6	6.9	9.4	7.9
Greece	16.8	16.6	17.5	16.8
Hungary	16.2	16.4	21.3	17.8
Ireland	7.3	8.2	9.5	8.2
Italy	13.8	14.0	16.1	14.5
Latvia	18.9	17.0	20.6	18.6
Lithuania	19.9	15.1	19.8	18.1
Luxembourg	4.5	4.6	8.1	5.7
Netherlands	5.5	5.5	8.9	6.6
Poland	19.0	15.7	19.0	17.7
Portugal	23.4	15.3	19.5	19.2
Romania	24.6	24.0	24.4	24.1
Slovakia	6.4	5.7	7.2	6.3
Slovenia	14.2	15.7	20.2	16.5
Spain	7.6	7.1	10.3	8.2
Sweden	4.1	5.0	5.5	4.8
United Kingdom	6.5	5.0	8.4	6.6

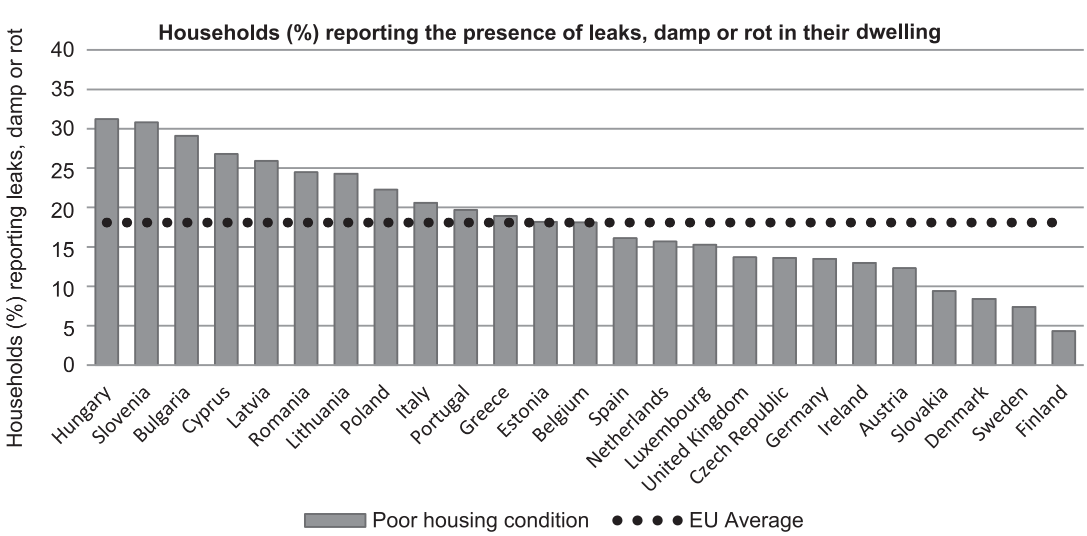

Fig. 3. Households in housing that has leaks, damp or rot by country, χ^2 (24)=3,325,530.94, $p= < .001$.

composite measure of fuel poverty in this way enables the interaction between the indicators and the usefulness of each proxy indicator to be explored.

In scenario one, ‘Households unable to pay to keep their home adequately warm’ is given strong preference and assigned a weight of .5, whilst the remaining two indicators are assigned a weight of .25 respectively. In this scenario, the highest levels of fuel poverty are found in Bulgaria (31.1 per cent), Cyprus (23.8 per cent) and Romania (24.6 per cent), whilst the lowest levels of fuel poverty are found in Denmark (2.7 per cent), Finland (3.8 per cent) and Sweden (4.1 per cent). In scenario two, ‘Households in arrears on utility bills’ is given strong preference and assigned a weight of .5, whilst the remaining two indicators are assigned a weight of .25 respectively. The lowest levels of fuel poverty are found in Denmark (3.3 per cent), Finland (4.7 per cent) and Luxembourg (4.6 per cent), whilst the highest levels are again found in Bulgaria (31.2 per cent), Cyprus (17.8 per cent) and Romania (24 per cent). In scenario three, ‘Households in housing that has leaks, damp or rot’ is given strong preference and assigned a weight of .5, whilst the remaining two indicators are assigned a weight of .25 respectively. As before, the highest levels of fuel poverty are found in Bulgaria (30.5 per cent), Cyprus (22.8 per cent) and Romania (24.4 per cent), and the lowest levels occur in Denmark (4.8 per cent), Finland (4.3 per cent) and Sweden (5.5 per cent).

In the final scenario, all three indicators are assigned an equal weight of .33. Similar levels of fuel poverty are found in this scenario compared with theprevious three scenarios, with the highest levels occurring in Bulgaria (30.6 per cent), Cyprus (21.2 per cent) and Romania (24.1 per cent), and the lowest levels occurring in Denmark (3.6 per cent), Finland (4.2 per cent) and Sweden (4.8 per cent). As seen in Table 2, the levels of composite fuel poverty are relatively stable across most countries for all four scenarios, with Cyprus, Hungary, Lithuania, Portugal and Slovenia showing the most variance between scenarios. Where there is little variance across the scenarios, this is an indication that all three indicators are equal measures of fuel poverty.

4.3. Modelling consensual measures of fuel poverty

Three logistic regression models have been constructed to predict household inability to pay to keep the home adequately warm, incurring arrears on utility bills and living in a house that has leaks, damp or rot. The explanatory variables have been selected on the basis of existing literature, understandings and explanations of fuel poverty, and are discussed in more depth in Table 1.

A stepwise entry procedure has been employed, with a backward likelihood ratio method. With this entry procedure, the logistic regression model begins with all the predictors included and calculations take place to determine which predictors can be removed without having a substantial effect on the model fit to observed data (Field, 2009, p. 272). A backward likelihood ratio method has been chosen as the forward method has a higher risk of making a Type II error (Field, 2009), whereby a test fails to reject a false null hypothesis.

4.3.1. Modelling inability to pay to keep the home adequately warm

In order to predict if a household would be unable to pay to keep their home adequately warm, a regression model was constructed using the dichotomous indicator ability to pay to keep the home warm, and the following predictor variables: arrears on utility bills, presence of leaks, damp or rot, ability to make ends meet, if more than three rooms are available to household, whether the household resides in a former socialist state, the household degree of urbanisation, and accommodation and tenure status. The best fitting logistic regression model is presented in Table 3.

All predictor variables added to the model were found to have an influence on a household’s inability to pay to keep the home adequately warm. Residing in a rural location increased the odds of being unable to heat the home adequately the most, by a factor of 1.057, whilst residing in an intermediate area of urbanisation also increased the odds of a household’s inability to pay to keep the home adequately warm, by a factor of .971.

A pseudo *R*-squared measure has been included in the analysis, Nagelkerke *R* Square, which is based on the log-likelihood of the model and the log-likelihood of the original model (Field, 2009, p. 269). Nagelkerke *R* Square indicates that the model shown in Tables 3 and 4 improves the prediction of the inability to adequately heat the home by 19.5 per cent.

Table 4
Logistic regression model statistics.

		df	Sig.
Model chi-square	16,001,265.65	12	[a]
−2 log likelihood	91,416,551.64		
Nagelkerke R Square	.195		
Overall % correctly predicted	89.5%		

[a] Significant at < .001

Table 3
Logistic regression model to predict household inability to afford to heat the home adequately.

Variables	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for Exp(B)	
							Lower	Upper
Arrears on utility bills (1=yes)	−.683	.001	766,935.972	1	[a]	.505	.504	.506
Presence of leaks, damp or rot (1=yes)	−.739	.001	1,488,372.681	1	[a]	.478	.477	.478
Ability to make ends meet (1=some difficulty)	−1.837	.001	4,881,463.327	1	[a]	.159	.159	.160
More than three rooms available (1=no)	−.218	.001	112,796.003	1	[a]	.805	.804	.806
Former socialist state (1=yes)	−.550	.001	606,199.637	1	[a]	.577	.576	.578
Intermediate urbanisation (1=yes)	−.030	.001	1621.525	1	[a]	.971	.969	.972
Rural (1=yes)	.055	.001	5806.769	1	[a]	1.057	1.056	1.059
Detached accommodation	−.291	.001	148,780.854	1	[a]	.747	.746	.748
Semi-detached or terraced accommodation	−.130	.001	24,766.360	1	[a]	.878	.877	.879
Market rate tenant	−.491	.001	352,145.654	1	[a]	.612	.611	.613
Submarket rate tenant	−.515	.001	255,478.520	1	[a]	.597	.596	.599
Free accommodation	−.439	.001	214,200.343	1	[a]	.644	.643	.646
Constant	4.286	.001	1.915E7	1	[a]	72.663		

[a] Significant at < .001.

Table 5
Logistic regression model to predict household arrears on utility bills.

Variables	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for Exp(B)	
							Lower	Upper
Ability to keep home adequately warm (1 = no)	.686	.001	776,118.474	1	[a]	1.986	1.983	1.989
Presence of leaks, damp or rot (1 = yes)	.678	.001	873,499.200	1	[a]	1.970	1.967	1.973
Ability to make ends meet (1 = some difficulty)	1.780	.001	2,842,908.921	1	[a]	5.928	5.915	5.940
More than three rooms available (1 = no)	.324	.001	165,897.877	1	[a]	1.383	1.381	1.385
Former socialist state (1 = yes)	.383	.001	204,575.688	1	[a]	1.466	1.464	1.469
Intermediate urbanisation (1 = yes)	.042	.001	2166.747	1	[a]	1.043	1.041	1.045
Rural (1 = yes)	.121	.001	19,514.376	1	[a]	1.129	1.127	1.130
Detached accommodation	−.023	.001	640.027	1	[a]	.978	.976	.979
Semi-detached or terraced accommodation	−.468	.001	175,767.765	1	[a]	.626	.625	.628
Market rate tenant	.355	.001	131,997.598	1	[a]	1.427	1.424	1.429
Submarket rate tenant	.039	.001	820.688	1	[a]	1.039	1.037	1.042
Free accommodation	.159	.001	18,829.675	1	[a]	1.173	1.170	1.175
Constant	−4.590	.001	1.438E7	1	[a]	.010		

[a] Significant at < .001

Table 6
Logistic regression model statistics.

		df	Sig.
Model chi-square	10,696,772.34	12	[a]
−2 log likelihood	67,697,117.69		
Nagelkerke *R* Square	.167		
Overall % correctly predicted	93.3%		

[a] Significant at < .001.

4.3.2. Modelling arrears on utility bills in last twelve months

Whether a household will experience arrears on utility bills is predicted using the dichotomous indicator arrears on utility bills. The predictor variables used are the same as for the inability to keep the home adequately warm regression, with the addition of the ability to keep the home warm variable. The model presented in Tables 5 and 6 are the best fit model from the stepwise regression modelling.

Experiencing some level of difficulty in making ends meet had the largest impact, with increased odds of incurring utility arrears by a factor of 5.93. The inability to pay to keep the home warm had the second largest impact, increasing the odds of arrears by a factor of 1.99, whilst the presence of leaks, damp or rot increased the odds by a factor of 1.97. The remaining variables all had an influence on the likelihood of a household incurring arrears. The pseudo *R* Squared value indicates the model improved the prediction of a household experiencing arrears by 16.7 per cent, compared to a model based on a constant value.

4.3.3. Modelling leaking roof, damp walls/floors/foundation, or rot in window frames or floor

A regression model to predict if a household would occupy housing that had leaks, damp or rot was created using the dichotomous indicator presence of leaks, damp or rot.

Tables 7 and 8 display the regression model and statistics.

All predictor variables added to the model were found to have an influence on whether a household occupied housing that experienced leaks, damp or rot. The largest influence was an inability to heat the home adequately, which increased the odds of living in a house with leaks, damp or rot by a factor of 2.10, whilst incurring arrears on utility bills increased the odds by 1.97. The pseudo *R* Squared value indicates the model improves the ability to predict whether a household lives in housing that contains leaks, damp or rot by only 9.6 per cent, compared to the base model, which is substantially lower than in the previous two models.

5. Concluding discussion

This paper has presented an analysis of fuel poverty across the EU, using standardised EU-SILC data, and a consensual measurement approach. This analysis is the largest cross-comparative analysis of European fuel poverty since Healy and Clinch's work (2002), and has highlighted the prevalence of fuel poverty across the European Union, particularly in newer member states such as Bulgaria and Romania. Based on the three proxy indicators in the dataset, fuel poverty is found to be a particular issue across Southern European countries, as previously found by Healy and Clinch (2002) and Eastern European countries as discussed by Buzar (2007), with Bulgaria, Cyprus and Romania consistently displaying the worst levels of composite fuel poverty across four scenarios.

Logistic regression modelling revealed that location had the largest impact on whether households in the EU reported an inability to heat the home adequately, with residing in a rural area having the largest impact, followed by residing in an intermediate area of urbanisation. This may be due to the higher levels of overall poverty found in rural areas, particularly in transition countries (Macours and Swinnen, 2008), and issues relating to available fuel sources. By contrast, experiencing some difficulty in making ends meet, and reporting an inability to heat the home adequately had the largest impact on the likelihood of a household experiencing arrears on utility bills. Similarly, reporting an inability to heat the home adequately and reporting arrears on utility bills had the largest impact on the likelihood of a household residing in a dwelling that had leaks, damp or rot, which shows the interaction between the three indicators chosen for analysis; if a household is struggling to afford to heat their home adequately, and utility bill debts have accrued, they are likely to restrict their use of heating, thereby causing damp and rot. Equally, a dwelling with damp and rot will in turn be more expensive to heat, as it will be more energy inefficient compared to a dwelling without these problems (see for example Goodacre et al. (2002)), thus potentially exacerbating fuel poverty. In policy terms, we argue that all three dimensions of fuel poverty considered in this research could (in part) be addressed through improved household energy efficiency, as it would potentially reduce energy bills (or make them more affordable), and both directly and indirectly address energy inefficiency associated with damp and rot. This is discussed further below.

Table 7
Logistic regression model to predict presence of leaks, damp or rot.

Variables	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for Exp(B)	
							Lower	Upper
Ability to keep home adequately warm (1 = no)	.743	.001	1,519,775.086	1	[a]	2.102	2.099	2.104
Arrears on utility bills (1 = yes)	.678	.001	882,221.530	1	[a]	1.970	1.967	1.972
Ability to make ends meet (1 = some difficulty)	.638	.001	1,610,044.398	1	[a]	1.892	1.890	1.894
More than three rooms available (1 = no)	.264	.001	260,344.451	1	[a]	1.303	1.301	1.304
Former socialist state (1 = yes)	.128	.001	44,857.201	1	[a]	1.137	1.135	1.138
Intermediate urbanisation (1 = yes)	.113	.001	38,113.072	1	[a]	1.120	1.118	1.121
Rural (1 = yes)	.251	.001	186,857.883	1	[a]	1.285	1.284	1.286
Detached accommodation	.453	.001	541,838.975	1	[a]	1.573	1.571	1.575
Semi-detached or terraced accommodation	.438	.001	476,807.593	1	[a]	1.549	1.547	1.551
Market rate tenant	.517	.001	635,085.896	1	[a]	1.677	1.674	1.679
Submarket rate tenant	.528	.001	395,198.900	1	[a]	1.696	1.693	1.698
Free accommodation	.296	.001	122,052.251	1	[a]	1.344	1.342	1.347
Constant	−2.826	.001	1.979E7	1	[a]	.059		

[a] Significant at $<.001$

Table 8
Logistic regression model statistics.

		df	Sig.
Model chi-square	9,355,493.98	12	[a]
−2 log likelihood	134,654,671.4		
Nagelkerke R Square	.096		
Overall % correctly predicted	83.3%		

[a] Significant at $<.001$

The EU has taken a prominent role in promoting energy security, climate change mitigation and sustainable development, with a range of policy measures in place, but policy specifically addressing fuel poverty has been limited, despite the clear relationship between climate change and fuel poverty. With increasing energy prices (as a result of a number of factors including increases in wholesale energy costs and environmental levies), economic hardship at both the household and national level, and reduced national welfare budgets, the trends presented here are likely to worsen rather than improve. As described in the introduction, there is a body of literature that suggests that the most effective policy response that unites the policy goals of fuel poverty and climate change prevention is a focus on improvements to the energy efficiency of domestic housing stock. Given the high levels of poor housing condition found in this research, and the relationship between housing condition, energy inefficiency and under-heating (Healy and Clinch, 2002), a policy of retrofitting energy efficiency measures in the domestic housing stock could have the multiple benefits of addressing Europe 2020 targets, improving the housing stock, whilst also reducing fuel poverty.

In addition to this, there is a significant EU based literature that considers the potentially regressive effects of climate policies that increase the cost of non renewable energy (see Tol (2007), Wier et al. (2005), Gough et al. (2008), Ürge-Vorsatz and Tirado Herrero (2012)). We argue that attention must be paid to any national level policies that are likely to increase household energy bills, as without appropriate protection in place these are likely to hit the poorest households the hardest, potentially pushing more households into fuel poverty.

To conclude, we argue that there are a number of key defining features of fuel poverty; location, housing quality, and income. When designing climate or energy policies we recommend that policy makers (at both the EU and national levels) recognise these features, and attempt to develop interventions that do not exacerbate fuel poverty. The data presented in this paper indicates the urgent need for a clearer and more coherent policy response to fuel poverty on a European level, in addition to action at the national level. Differences at the national level also need consideration, and a focus on rural areas, especially in countries with poor energy infrastructure, and with high levels of rural poverty is essential. It is beyond the scope of this paper to consider this issue in more depth, but, more research is needed to understand and address this problem.

In light of the requirements laid out in European Council Directive 2009a,b for affected Member States to develop action plans, it is clear some countries will need to start identifying and addressing fuel poverty, and this should be implemented in conjunction with other policy objectives. However, further research is necessary to examine the household composition of fuel poor households across the EU and to explore trends of fuel poverty across time, based on the proxy indicators outlined in this paper. The addition of micro-data regarding household fuel spend would also enable a comparison of expenditure and consensual measures of fuel poverty, however, at present this data is unavailable.

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