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Energy Poverty in the EU:

State of the art in research and policy directions

Κοντούλη Νικολέττα

Α.Μ. 11016

Ιωάννης Παραβάντης, Επίκουρος Καθηγητής ΠΑΠΕΙ

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Η υπογράφουσα Κοντούλη Νικολέτα βεβαιώνω ότι το έργο που εκπονήθηκε και παρουσιάζεται στην υποβαλλόμενη διπλωματική εργασία είναι αποκλειστικά ατομικό δικό μου. Όποιες πληροφορίες και υλικό που περιέχονται έχουν αντληθεί από άλλες πηγές, έχουν καταλλήλως αναφερθεί στην παρούσα διπλωματική εργασία. Επιπλέον τελώ εν γνώσει ότι σε περίπτωση διαπίστωσης ότι δεν συντρέχουν όσα βεβαιώνονται από μέρους μου, μου αφαιρείται ανά πάσα στιγμή αμέσως ο τίτλος.

(υπογραφή)

Abbreviations glossary

ACA Asociación de Ciencias Ambientales

AHC After Housing Costs

Anah Agence nationale de l' habitat

ASHP Air-Source Heat Pumps

BAFA Bundesamt für Wirtschaft und Ausfuhrkontrolle

BHC Before Housing Costs

CERT Carbon Emission Reduction Target

CESP Community Energy Savings Program

CT Council Tax

CO_2 Carbon Dioxide

CWI Cavity-Wall Insulation

DECC Department of Energy and Climate Change

DHSS Department of Health and Social Security

DLA Disability Living Allowance

DTI Department of Trade and Industry

ECE Eastern and Central Europe

ECO Energy Company Obligation

EESC European Economic and Social Committee

EFRA Environment Food and Rural Affairs

EFUS Energy Follow-up Survey

EHS English Housing Survey

EHCS English House Condition Surveys

EP European Parliament

EPEE European Fuel Poverty and Energy Efficiency

ESS European Statistical System

EU European Union

EU SILC European Union Statistics on Income and Living Conditions

EWD Excess Winter Death

FP-MACC Fuel Poverty-Marginal Alleviation Cost Curve

FPR Fuel Poverty Ratio

FYROM Former Yugoslav Republic of Macedonia

GSHP Ground-Source Heat Pumps

HB Housing Benefit

HBAI Households Below Average Income

HBS Household Budget Surveys

HDI Human Development Index

HECA Home Energy Conservation Act

ISMI Income Support for Mortgage Interest

LIHC Low Income High Costs

LILC Low Income Low Cost

MIG Minimum Income Guarantee

MIS Minimum Income Standards

MPPI Mortgage Payment Protection Insurance

NEA National Ecosystem Assessment

NELA German acronym for "Sustainable Energy Consumption and Lifestyles in Poor and at- Risk-of-Poverty Households"

NHS National Health Service

NICE National Institute for Health and Clinical Excellence

OFGEM Office of the Gas and Electricity Markets

PQLI Physical Quality of Life Index

RCC Rural Community Councils

RHS Residential Heating Systems

SAP Standard Assessment Procedure

SDLP Social and Democratic Labour Party

SDOB Statistical Distribution of Buildings

SEM Structural Equation Model

SHCS Scottish House Condition Survey

SOEP Socio-Economic Panel

TRV Thermostatic Radiator Valve

UK United Kingdom

WHD Warm Home Discount

WHECA Warm Homes and Energy Conservation Act

WHO World Health Organization

Ευχαριστίες

Ευχαριστώ θερμά τον Επίκουρο Καθηγητή Ιωάννη Παραβάντη για την πολύτιμη υποστήριξη και καθοδήγησή του καθ'όλη τη διάρκεια της συνεργασίας μας, στα πλαίσια της εκπόνησης την εν λόγω Διπλωματικής Εργασίας. Η εμπιστοσύνη που μου έδειξε, δίνοντας μου την ευκαιρία να συμμετέχω στη συγγραφή μιας επιστημονικής εργασίας, αποτέλεσε για εμένα σπουδαία εμπειρία και το εναρκτήριο λάκτισμα για την υλοποίηση της παρούσης μελέτης.

Ευχαριστώ τους Καθηγητές του Τμήματος Διεθνών και Ευρωπαϊκών Σπουδών, η συμβολή των οποίων στη διαμόρφωση της επιστημονικής μου ιδιότητας, αναφορικά με το γνωστικό αντικείμενο των Διεθνών και Ευρωπαϊκών Σπουδών, υπήρξε σημαντική.

Επίσης, θέλω να ευχαριστήσω τη διεύθυνση του Τμήματος Διεθνών και Ευρωπαϊκών Σπουδών για τη δυνατότητα που μου δόθηκε, να συγγράψω την παρούσα εργασία στην αγγλική γλώσσα, κατόπιν σχετικής ρύθμισης.

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CHAPTER 1: Introduction

1.1 Scope of the study

This postgraduate thesis investigates the problem of energy poverty. A key aspect of this thesis is to present the phenomenon within the Member States of European Union (EU). Leading country is the United Kingdom (UK), as it has first formulated the definition of fuel poverty and has implemented policies to combat it.

Whether a household is in fuel poverty is determined by the interplay across three factors: (a) the energy efficiency of the property, (b) energy costs and (c) household income. Considering that the main causes of fuel poverty are common throughout the EU, there will be presented programs for energy conservation and energy efficiency as part of the policies of the EU against fuel poverty.

1.2 Introduction

The European Union (EU) has no official meteorological definition of cold and extreme cold. A Dutch study defines a cold spell as a period of at least 9 consecutive days in which the lowest temperature reaches -5°C or lower, including at least 6 days in which the lowest temperature touches -10°C or lower. The World Health Organization (WHO) recommends healthy indoor temperatures are between 18 ^{o}C and 21 ^{o}C (WHO, 1987). A 2006 WHO review of 10 countries, within the WHO European Region, estimated that the attributable fraction of excess winter deaths due to housing conditions was around 40% (WHO, 2007).

According to Boardman (2010), energy poverty or fuel poverty, is a phenomenon whereby a household struggles to *"afford adequate services... clearly demonstrated when the home is cold or fuel debts accumulate"*. Fuel poverty is a recognized social problem that affects the poor, with its roots in the quality of the housing stock and cost of fuel (Boardman, 1991). While this has been acknowledged by campaigners and academics since at least 1975, political acceptance has been slower. The following is not an extensive history, but includes some of the main events that occurred from 1991 to today's context. Many of the reports cited have covered fuel poverty in the context of energy policy, presumably because of the name "fuel poverty".

Poverty and fuel poverty are linked, but not synonymous concepts (Boardman, 2010). Fuel poverty is defined as a difficulty, or even incapacity to have proper heating in one's home, all this at a reasonable cost. This form of poverty is still not very well defined in most of the countries. Only UK has taken this problem into account by defining it. National surveys on housing conditions gather data on households' incomes, taxes heating system as well as level of accommodation, isolation and households' characteristics. These surveys constitute the main source to evaluate fuel poverty.

Fuel poverty is caused by an interaction between high energy bills, low income and poor energy efficiency, in addition to supplementary determinants such as housing tenure and quality of energy supply.

Outside Boardman's (2001, 2010) work in the UK, there are only two academic monographs on fuel poverty in Europe, focusing on these issues in the context of the "old" EU-15 member states (Healy, 2004), and the post-communist countries in Eastern and Central Europe (Buzar, 2007). In response, while it has become common place to call attention to energy poverty in the context of developing countries in the global South, there is much less theoretical and empirical coherence when referring to issues of inadequate thermal comfort and domestic energy deprivation in the global North. In particular, knowledge about energy poverty in continental Europe is in a fetal stage, despite the recent completion of a pan-European research project which emphasized that *"retired people, those out of work or in poorly paid jobs, and those dependent on social security benefits"*, as well as *"elderly, disabled or single parent families"* are at the highest risk of falling into fuel poverty (EPEE, 2009).

While the term fuel poverty is used throughout this thesis, it does not imply that a household is actually fuel poor or poor in general. The term should be interpreted in the sense that a household identified as fuel poor is potentially strongly impacted by the costs of energy services or alternatively can be regarded as a vulnerable energy consumer in accordance to the EU Commissions definition in the directives for the harmonization of European energy markets (EU, 2009a, 2009b).

1.3 Structure of thesis

In this thesis, there will be a thorough mention for the fuel poverty in the EU, where the EU is the leading international player on climate change and committed to firm policies to be achieved by 2020: the so-called 20/20/20 package requires, in relation to 1990, cutting greenhouse gases by 20%, producing 20% of primary energy from renewables, and improving energy efficiency by 20% (Boardman, 2010). The renewable energy target carries the most weight – there are financial penalties if it is not achieved.

At the moment there is no consistent approach within the EU when defining criteria to identify people living in fuel poverty. Nevertheless, there are several approaches identifying categories of people with problems in securing a sufficient amount of energy to meet their needs.

Globally, the term "energy poverty" recognizes the lack of access to basic energy services, i.e. electricity and clean cooking facilities, and is used by international organizations. Energy poverty affects from 1.3 billion to 2.6 billion people from underdeveloped regions of the world and represents a major barrier to economic growth as well as for the health and wellbeing of the people.

In the EU, the problem of having access to electricity and energy services is no longer an issue. However, affordability of energy services is. This is generally recognized by the term "fuel or energy poverty". According to several evaluations, it is estimated that between 50 and 125 million Europeans are currently fuel poor.

Despite lacking a common European definition, the European Council Directive 2009/72/EC acknowledges that fuel poverty not only exists but also is a growing problem in the Community that needs to be directly addressed. The Directive also states the connection between fuel poverty and vulnerable consumers as it mentions that *"each Member State shall define the concept of vulnerable customers which may refer to energy poverty and, inter alia, to the prohibition of disconnection of electricity to such customers in critical times"*. The Directive does not foresee a common definition for vulnerable consumers to be implemented at national levels, but instead focuses on the existence of different (social) support mechanisms.

In the chapter *An introduction to fuel poverty* (Chapter 2) the focus is on the history and the evolution of the definition of fuel poverty, of vulnerable households and the efforts to measure fuel poverty across the Member States of EU.

Chapter 3 a *literature review*, explores the surveys held in UK, where the term fuel poverty was first defined in Brenda Boardman's book of 1991. Literature review of other European countries is presented too. Special reference is made to Greece. Much of the research is presented in this part of the thesis was published in the paper *"Financial crisis and energy consumption: A household survey in Greece"*, which is included in the appendix.

Chapter 4 *Energy policy directions* investigates and presents policies that are implemented, in EU giving an emphasis in the UK, towards the elimination of fuel poverty.

The final chapter *Conclusions* (Chapter 5) includes an overview of what has preceded in the previous chapters, the conclusions of the investigations carried out and recommendations for further study.

CHAPTER 2: Fuel poverty over time

2.1 Definition of fuel poverty

While "fuel poverty" had been named and defined in broad terms by at least the early 1980s (Bradshaw and Hutton, 1983), it was given a specific term in Brenda Boardman's book of 1991 to cover households whose fuel expenditure on all energy services exceeded 10% of their income (Boardman, 1991).

This was what the poorest 30% of households were then spending on fuel and, at twice the median expenditure, was a threshold above which spending was considered "disproportionate". To determine the scale of the problem of "affordable warmth", the 1991 English House Condition Surveys (EHCS**)** Energy Report adopted the 10% of income threshold for fuel expenditure (DOE, 1996). However, rather than actual fuel expenditure, it used the fuel costs required to achieve either a minimum heating regime to safeguard health or a standard regime to provide thermal comfort, plus adequate lighting, cooking and typical appliance use (Moore, 2012).

The Fuel Poverty Ratio (FPR) is defined as:

Fuel poverty ratio= modeled consumption x *price/ income*.

If this ratio is greater than 0.1 then the household is Fuel Poor (DECC, 2012a). FPR compares the cost of energy consumption to the income of a household (Hills, 2012) and is an interaction of three factors: the energy efficiency of the household, the cost of energy and the household income (DECC, 2010).

The 1996 Energy Report further revised the definition by requiring "satisfactory" heating (EHCS, 1996). This comprised a full, standard or partial heating regime, depending on the household type and level of occupancy. Both the 1991 and 1996 EHCS definitions used the actual fuel prices of households to calculate fuel costs. However, the 2001 EHCS dropped the fuel consumption and tariff survey and since then the calculation of fuel poverty has been based on average regional fuel prices, broken down by payment type. In 2001, fuel costs were also based on modeled occupancy rates and by 2003, as well as Housing Benefit (HB**)** and Income Support for Mortgage Interest (ISMI**)**, Mortgage Payment Protection Insurance (MPPI) had been included in full income.

Following a 2005 Government initiated peer review on the methodology for measuring fuel poverty, the computation of household incomes from any additional benefit units was improved and Council Tax (net of any CT benefit) was omitted from all full incomes (Sefton and Chesshire, 2005). The fuel costs for hot water, lights and appliance use were also updated and rebased on actual occupancy. Subsequently, the EHCS based incomes were made more compatible with those from the Family Resources Survey and a fourth “partial-standard” heating regime was added. To avoid excess seasonal mortality, homes need to be kept cool in summer as well as warm in winter and, in many dwellings this may increasingly require some form of mechanical air-conditioning.

As with incomes, however, there are questions about the way total fuel costs are measured. Despite improvements, the “algorithms” used for calculating the non-space heating costs are still too generalized. The Government’s use of average fuel prices is also likely to significantly under-estimate fuel poverty as those at risk tend to be on higher than average tariffs for their region and payment type. However, the ongoing 2011 EHS Energy Follow-up Survey (EFUS) should enable any under-estimation to be assessed (DECC, 2013a)

Although there is no single, universally accepted definition of poverty, outside the third world, poverty is now generally considered to be relative. For example, the European Union’s working definition of poverty is: *“Persons, families and groups of persons whose resources (material, cultural and social) are so limited as to exclude them from the minimum acceptable way of life in the Member State to which they belong”*. In line with this primary definition, the Households Below Average Income (HBAI) series uses relative incomes on both a Before Housing Costs (BHC) and After Housing Costs (AHC) basis and adopts a 60% of median income as a proxy for the poverty line.

With increasing fuel prices, pressure to tackle fuel poverty has been growing across Europe and the amended European Commission’s third electricity and gas directives of 2009 call upon all Member States to develop national action plans or other appropriate frameworks to tackle energy poverty (Directives 2009/72/ EC, 2009). Earlier, an European Fuel Poverty and Energy Efficiency (EPEE) project paper had noted that, of the participating countries, only the UK had any official definition of fuel poverty (EPEE, 2006).

It is more meaningful, therefore, to measure fuel poverty with reference to the fuel costs required to maintain adequate thermal comfort, safeguard health and cover other normal fuel usage, irrespective of actual fuel spending. However, this requires a detailed knowledge of the energy efficiency of the housing stock. The UK is almost unique in having a series of large national house condition surveys that enable such fuel costs to be accurately determined and compared directly with corresponding household incomes.

2.2 History and evolution of the definition of the fuel poverty

2.2.1 A short history of fuel poverty

The current definition of fuel poverty has accumulated and evolved since 1991 and a little bit of history is needed to provide the background situation. The original definition of fuel poverty was that it occurred when a household could not *"have adequate energy services for 10% of income"* (Boardman, 1991).

Table 2.1: *Historical progression of the fuel poverty definition*

Year	Historical progression of the fuel poverty definition
1973-1974	Government phases out subsidies for gas and electricity. Oil crisis forces up energy prices
1976	Child Poverty Action group highlight impact of rising fuel prices on poor (Johnson & Rowland, 1976)
1979	Isherwood & Hancock define the fuel poor as: *"those spending more than twice the median (i.e. 12%) on fuel, light and power"*
1980	Richardson defines fuel poverty as: *"the situation where following recent fuel price increases, people are unable to afford the fuel they need for heating, lighting and cooking"*
1982	Lewis defines fuel poor as: *"the inability to afford adequate heat in the home"*
1983	Bradshaw & Hutton define fuel poverty as: *"Social problems associated with fuel (are)... a major issue in their own right"*
1988	Boardman completes her doctoral thesis makes first quantifiable definition of fuel poverty
1991	Boardman publishes first book on fuel poverty. Defines fuel poverty as: *"...the inability to afford adequate warmth because of the inefficiency of the home"*
1997	Labour party elected to government. Fuel poverty adopted in government terminology
2000	Private Members Bill Warm Homes and Energy Conservation Act (2000) ratified into law. Act required: *"the Secretary of State to publish and implement a strategy for reducing fuel poverty"*
2001	UK Fuel Poverty Strategy published. Defines a fuel poor household as" *"...one that cannot afford to keep adequately warm at reasonable cost"*
2016	Target date for the eradication of fuel poverty *"as far as reasonably practicable"* as specified in the WHECA in the UK Fuel Poverty Strategy

This was based on 1988 data when household average expenditure on energy for use in the home was 5% of the weekly budget, and the 30% of households with the lowest income did, indeed, spend 10%. The figure of 10% was, therefore, in some sense "affordable" for the poorest households. It was what they were spending, although they were often cold as well. Another reason for taking 10% was that work by two economists at the Department of Health and Social Security (DHSS) had stated that expenditure at a level equivalent to twice the median is "disproportionate" (Isherwood and Hancock, 1979).

The term "fuel poverty" is defined in legislation, in the Warm Homes and Energy Conservation Act 2000 (WHECA) originally a Private Member's Bill. This stated that *"For the purposes of this Act 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"*.

As the Government said in its October 2009 response to the Environment Food and Rural Affairs (EFRA) committee report on Energy Efficiency and Fuel Poverty, *"Under the fuel poverty definition, income needs to increase substantially more in absolute terms than the energy price rises to remove a household from fuel poverty"*.

As opposed to defining household fuel or energy poverty line, authors such as Goldemberg and Johansson, (1995) or Krugman and Goldemberg, (1983) had defined energy poverty by assessing energy consumption at the aggregate national level in relation to other broader measures of poverty such as the Human Development Index (HDI) or Physical Quality of Life Index (PQLI). For households, this only occurs with expenditure on housing and with fuel. There were – and are – policies designed to assist with housing costs and thus reduce the impact (e.g. housing benefit).

For fuel poverty, the hardship was not ameliorated, indicating that the fuel poor needed assistance. Policies to tackle fuel poverty specifically could be justified. The Isherwood and Hancock (1979) definition of twice the median indicated that the households in the lowest three deciles who had disproportionate fuel expenditure, confirmed the approach that had to be taken. The "catchment" area for the fuel poor was not the lowest two deciles or some other proportion, but the 30% of households with the lowest incomes.

2.3 Components of fuel poverty

According to Boardman (2010), there are several components to the definition of fuel poverty and these have been defined at different times by a variety of sources. They are predominantly linked to technical, quantifiable factors, rather than social ones, such as self-assessed comfort or ability to pay the fuel bill.

The first two components of fuel poverty are based on World Health Organization (WHO) standards and are presented in Table 2.2 below. The temperatures shown for whole house heating roughly approximate to a 24-hour mean internal temperature of 16°C to 17°C, less in really energy-inefficient homes, where the temperature drops quickly when the heating is off. Scotland uses a higher temperature of 23°C in the living room for elderly (60+), disabled and infirm households (self reported) and 18°C elsewhere, for 16 hours a day (SHCS, 2006).

Table 2.2: *Constituent parts of the definition of fuel poverty* (Boardman, 2010)

Component	Description	Source
Temperature	21°C in the living room;18°C elsewhere *	England: DOE (1996, pp129, 83) UK: DTI (2001, p6)
Hours of heating	9 hours a day for those at work or in full-time education; 16 hours for those likely to be at home all day	England: DOE (1996, pp129, 83)
Proportion of house	All rooms, unless under-occupied (i.e. more space and bedrooms than the Parker Morris standard), in which case only half the space is heated *	DTI (2001, p144) England: Defra (2006, p15)
Energy for all energy services	Based on Building Research Establishment Domestic Energy Model (BREDEM), related to number of people and/or size of dwelling	England: DOE (1996, pp379–380); DTI (2001, p30)
Need to spend	Calculated in the fuel poverty model	UK: DTI (2001, p6)
Proportion of income	10% of income (however income is defined)	Boardman (1991, p227) UK: DTI (2001, p6) England: DTI (2001, p30)
Definition of income	Full income, including housing benefit and income support for mortgage interest (ISMI). Scotland only includes up to two household members	England: DTI (2001, pp30, 108) Scotland: DTI (2001, p50); Hulme (pers comm)
Vulnerable	Householders aged 60+, families with children, disabled or with a long-term illness	UK: DTI (2001, pp8–9)

*Scotland uses a higher temperature of 23°C for the elderly and infirm and does not adjust for under-occupancy.

2.3.1 Proportion of the house

There has been no debate about the reduction for under occupation, although this is likely to mean that anyone who is under occupying and is in fuel poverty is, in reality, in severe fuel poverty: their situation is much worse than calculated because it is often difficult to close off half the house (Sefton and Chesshire, 2005). Scotland does not use the half-house approach.

2.3.2 All energy services

The definition of fuel poverty has always included all energy services in the home, not just heating, although this has not always made explicit, even in government documents. Undoubtedly, some of the confusion has been encouraged by the phrase "affordable warmth". However, households need hot water, lighting, cooking and all the other uses of energy in the home, and this is recognized. For other uses of energy, there is less precision on the standard to be achieved than for heating, partly because there have been few attempts at defining adequate hot water, lighting or other energy uses (Sefton and Chesshire, 2005).

2.3.3 Need to spend

Although implicit in the original definition, this has been clearly stated subsequently in order to include those that are restraining expenditure and are cold.

2.3.4 Proportion of income

The 10% figure has stayed although that was calculated on the basis of the proportion of the weekly budget (the only statistics available) in 1988. It has subsequently, and correctly, been redefined as 10% of income. For the poorest households, there is rarely any difference: they spend all their income and do not save. For better-off households the difference is important as their income is often considerably larger than their expenditure. Using the proportion of income means that richer households are rarely included, which is appropriate.

2.4 Vulnerable households: definition

For the purpose of fuel poverty a "vulnerable" household is measured as one containing elderly or disabled people, children or the long-term sick. It is these groups who are likely to be more vulnerable to cold-related ill health (DTI, 2001). A recent pan-European research project emphasizes that *"retired people, those out of work or in poorly paid jobs, and those dependent on social security benefits"*, as well as *"elderly, disabled or single parent families"* are at the highest risk of falling into fuel poverty (EPEE, 2009).

As fuel poverty is a measure of what a household needs to spend on energy rather than what it actually spends, total energy needs are modeled. In each of the home countries this is based on findings from surveys of households and the housing stock. This takes various factors into account including the size and energy efficiency of the property, household size, household type and type of heating. The modeled energy needs are then multiplied by appropriate fuel prices to reach a figure for total fuel costs.

In England, the English Housing Survey (EHS) is used for the modeling of needs. This has an annual sample size of around 8000 and fuel poverty reports are based on findings about households and the housing stock over two years. For instance the 2007 findings relate to fieldwork carried out between April 2006 and March 2008. This allows for more detailed analysis of the groups affected, but it does mean that the impact of price rises is staggered. This is particularly important at a time when prices were rapidly increasing. The duration of fieldwork, along with the time taken to process, analyze and validate the data, explains why there is a lag in reporting fuel poverty.

If fuel poverty is only about the ability of households to afford required fuel costs then, arguably, the Minimum Income Standards (MIS) is based on estimates which provide the most meaningful assessment yet of the scale and distribution of the problem. However, the UK Fuel Poverty Strategy defined fuel poverty for all households and also set targets for first eradicating the problem *"as far as is reasonably practicable"* in vulnerable households by 2010 and then in all households by 2016 (Defra, 2004) and 2018 in Wales.

Using a much broader classification than used in other policies, vulnerable households are defined as those containing *"older householders, families with children and householders who are disabled or suffering from a long term illness"* (DTI, 2001). The raison d'etre for giving vulnerable households priority was clearly due to the health risks associated with fuel poverty.

2.4.1 Fuel poverty in rural areas

Elderly people in rural areas are susceptible to particularly high levels of fuel poverty for a myriad of reasons including lack of access to a gas network, large detached dwellings and high levels of owner occupation (Lawlor et al., 2002). It has been calculated that lack of access to gas in many rural areas across the UK results in these areas typically spending 40% more on their total energy use when restricted to alternative forms of fuel (CSE/NRFC, 2001). Poor housing conditions are frequently associated with other elements of social disadvantage and in rural areas the amalgamation of contributing factors determines the energy efficiency of homes. Although Lawlor et al. (2002) found no association between rurality and Excess Winter Death (EWD) they concluded that rural householders may protect themselves by living "predominantly in one or two heated rooms" effectively causing spatial shrinkage within the home. Although the recently published fuel poverty strategy in Northern Ireland found little differences in the rate of fuel poverty between urban and rural areas, the strategy acknowledged that fuel poverty in rural areas was particularly difficult to address due to the high levels of owner occupation, isolation and lack of access to certain fuels (DSD, 2004). The hidden manner of rural fuel poverty has been acknowledged but to date little research has been carried out into the extent and nature of fuel poverty in rural areas.

2.4.2 Health effects of fuel poverty

Researches that have been carried out has provided crucial evidence linking people's life experience, their physical or mental health, to the quality of the housing stock. In numerous studies it has been found that younger people were more likely to report improvements in health and the conditions suffered by older people less likely to improve (Smith et al., 1997). This could be due to the nature of the illnesses suffered by older people, many of which are longstanding, and the deteriorating effects of aging (Blackman et al., 2003; Smith et al., 1997).

The conditions most likely to improve were depression and mental illness and improvements in social outcomes, such as trust, safety and social and community participation (Blackman et al., 2003; Elton and Packer, 1987). Consequently fewer studies have reported an improvement in physical health, or a reduction in the use of health services (Hunt and Mckenna, 1992; Somerville et al., 2002). This level of change is related to how much the individuals themselves feel that there is a direct connection between their health, physical or mental, and the problems in their homes. The consistent pattern of improvements in mental health would suggest a greater sense of connection between mental wellbeing and housing deprivation. In addition, these "improved" experiences relate to how effective people perceive the interventions to be and whether health improvements are due to the intervention, or to the overall feeling that the respondent now resides in a "healthier home". Such a "placebo" effect has been recognized in the literature (Blackman et al.,2003; Smith et al., 1997).

2.5 Measuring fuel poverty

2.5.1 Using the 10% definition

Accurate measurement of fuel poverty is necessary for a number of reasons. It enables policy makers, support groups and the population at large scale to understand how many people are living in fuel poverty whilst developing a picture of how it is evolving over time. An accurate measurement also facilitates meaningful evaluation of initiatives to eradicate fuel poverty and helps target resources where they are needed the most.

While the concept of fuel poverty is receiving increasing attention across many countries, its measurement and definition still predominantly focuses on that offered by Boardman and utilized by the UK government. The UK Fuel Poverty Strategy (2001) states: *"...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"*(DTI, 2001).

The greatest strength of this measure is its focus on modeled energy needs rather than actual energy consumption, meaning it is not influenced by households that choose to keep their homes at a cooler or significantly higher temperature.

The MIS can be used with data from the EHS to estimate the number of households in fuel poverty. In this context, households are deemed to be in fuel poverty if, after deducting their actual housing costs, they have insufficient residual net income to meet their total required fuel costs (as measured by the EHS) after all other minimum living costs (as defined by the MIS) have been met. Conversely, a household is in MIS based fuel poverty if: *Fuel costs (EHS) = Net household income (EHS) – housing costs (EHS) – minimum living costs (MIS)* (Smith et al., 2010).

2.5.2 Subjective and objective measures of fuel poverty

Within the UK, the EHCS has been used to link subjective and objective measures of fuel poverty (Waddams Price et al., 2012). The 1996 EHCS, the latest where fuel expenditure was included, found that only 5% of respondents said that they could not afford heating, while 12% were spending more than one tenth of their income on household energy. More recently, in 2003 around 7% of respondents self-reported fuel poverty, while 6% were fuel poor by more conventional definitions, though correspondence between objective and subjective measures, particularly for pensioner respondents, is often low (Hills, 2011).

Palmer et al.(2008) show that the link between fuel poverty and other measures of deprivation is weakening as energy prices rise. The importance of recognizing the varying needs and situations of different household needs in an international context is shown in Makdissi and Wodon (2006) whereas Scott et al.(2008) compare the high official levels of fuel poverty in Ireland with a self- reported measure of deprivation, and find that the latter is less than half the former.

Information from a unique data set have been used in order to link an objective measure based on expenditure as a proportion of income with a subjective assessment similar to that devised from the EHCS, and identify how achieving the objective target might affect subjective experiences.

Currently, the EU Statistics on Income and Living Conditions are the only standardized data available to measure pan- European fuel poverty. Using European Union Statistics on Income and Living Conditions (EU SILC) data, it is found that issues of fuel poverty exist across the EU, particularly in Central, Eastern and Southern Europe (Thomson & Snell, 2013).

2.5.3 Available data for measuring fuel poverty in EU

At the European level, there is no specialized survey of fuel poverty and energy affordability, and an absence of standardized household micro data on fuel expenditure. At present, the main two sources of data are the EU Statistics on Income and Living Conditions (EU SILC) and the Household Budget Surveys (HBS).

2.5.3.1 EU Statistics on Income and Living Conditions (EU SILC)

The EU-SILC is an instrument aiming at collecting timely and comparable cross-sectional and longitudinal microdata on income, poverty, social exclusion and living conditions. This instrument is anchored in the European Statistical System (ESS). The EU-SILC project was launched in 2003 on the basis of a "gentlemen's agreement" in six Member States (Belgium, Denmark, Greece, Ireland, Luxembourg and Austria) and Norway. The start of the EU-SILC instrument was in 2004 for the EU-15 (except Germany, the Netherlands, the United Kingdom) and Estonia, Norway and Iceland.

The EU-SILC instrument provides two types of data:

- Cross-sectional data pertaining to a given time or a certain time period with variables on income, poverty, social exclusion and other living conditions.
- Longitudinal data pertaining to individual-level changes over time, observed periodically over a four-year period.

The EU SILC offers comparable statistics on income, living conditions and social exclusion, with an annual sample of approximately 100,000 EU households. Three indicators from the EU SILC dataset have been widely used to measure aspects of EU fuel poverty, namely, inability to keep adequately warm, living in a damp home, being in arrears on utility bills. Table 2.3 shows that across the EU as a whole, nearly 10% of the population are unable to keep their home adequately warm, almost 16% live in homes that are damp, rotting or leaking, and around 9% are behind on payments for utility bills.

EU SILC is the largest standardized dataset currently available at EU level and as such is the best available data.

Table 2.3: *EU27 results for the main EU SILC indicators* (Thomson, 2014)

Indicator	2010 (%)	2011 (%)
Ability to keep home warm	9.5	9.8
Leak, damp, rot	16.0	15.5
Arrears on utility bills	8.9	8.9

2.5.3.2 Household Budget Surveys (HBS)

Household Budget Survey (HBS) are conducted in all EU countries to collect data on household expenditure on goods and services, including household energy. The main purpose of HBS is to compile weights for Consumer Price Indices and national accounts (Eurostat, 2014). Unlike EU SILC, which is an annual survey, HBS surveys are conducted irregularly across Europe, with the latest data reference years ranging from 2005 onwards.

Using HBS, the average (mean) household expenditure on energy as a proportion of income has been calculated for each country. The EU27 average is 7-8%, and the highest average expenditure is found in Slovakia (14.5%), whilst the lowest is found in Malta (1.8%) (EC, 2010).

2.6 Efforts to quantify fuel poverty

Domestic energy-efficiency levels vary considerably across Europe (Healy, 2002). Certain countries prioritize thermal efficiency in the design and construction of new housing, as it is essential protection to combat the relatively severe winters experienced in these colder climates where winter temperatures are often below freezing (Boardman, 1991). Despite enduring relatively mild winters, Ireland and the UK have the highest rates of seasonal mortality in northern Europe, and it has been shown that such mortality rates result, in no small part, from the inadequately protected, thermally inefficient housing stocks in these countries (Clinch and Healy, 2000a; Curwen, 1991). There are also strong associations between inadequately heated homes and increased rates of morbidity; higher incidences of various cardiovascular and respiratory diseases have been associated with chronic cold exposure from within the home through living in fuel-poor conditions (Collins, 1986; Evans et al., 2000). Thus, when temperatures fall during a typical British or Irish winter, households need to increase their expenditure on fuel considerably to heat their home adequately, owing to the poor level of heat retention in their dwellings.

The problem of fuel poverty occurs, therefore, when a household does not have the adequate financial resources to meet these winter home-heating costs, and because the dwelling's heating system and insulation levels prove to be inadequate for achieving affordable household warmth (Clinch and Healy, 2004). In addition to the public-health policy implications of fuel poverty, many countries demonstrating poor levels of domestic energy efficiency are consuming greater amounts of energy than necessary, as individuals inhabiting inefficient dwellings must consume more fuel to heat their homes adequately. This is of considerable importance given that many European countries —most notably Ireland—are having extreme difficulty in meeting their agreed targets for stabilization of greenhouse gas emissions under the Kyoto Protocol and acidification precursors under the Gothenburg Agreement (Clinch and Healy, 2000b).

Studies by the UK Government and other research (Milne and Boardman, 2000) confirmed both the persisting nature and considerable scale of the problem in the UK. However, this research is based on a standard expenditure approach to calculating fuel poverty, in which households spending more than 10% of income on home heating are deemed "fuel poor". This approach has many limitations.

First, it can be misleading, as several formulas now exist for calculating fuel poverty, some with housing costs included in net household income, other calculations exclude housing costs from the denominator of the formula, while other calculations analyze gross household income as opposed to net. Second, there does not appear to be any substantial rational behind setting the budget line at 10% of net income, and, therefore, this approach has been seen by some as lacking in any scientific basis. Third, such a definition is not useful for cross-country comparisons of fuel poverty, especially in countries (e.g. Ireland) where such data is unavailable. Fourth, studies using this method to quantify fuel poverty in the UK (e.g. DETR, 1999) have reported levels far greater than those using approaches based on social indicators of deprivation (e.g. Healy, 2003; Whyley and Callender, 1997) which has led some commentators to wonder whether the two approaches are measuring the same type of fuel poverty, i.e. persistent versus intermittent fuel poverty.

2.6.1 The Hills Review 2012 as a the most prominent quantifying effort

Professor John Hills conducted an independent review of fuel poverty for England and Wales, for Department of Energy and Climate Change (DECC). Hill's interim report *"Fuel Poverty: The problem and its measurement",* was published in October 2011 and his final report *"Getting the measure of fuel poverty: Final report of the fuel poverty review",* was published in March 2012.

The terms of reference for the review included three issues: First, whether fuel poverty is, in fact, a distinct problem, or simply a manifestation of more general problems of poverty. Second, if it is distinct, how it is best measured and whether the current approach to doing this captures the problems most effectively. Third, the implications of measurement for the way people understand the effectiveness of the range of policy approaches to reducing it.

The definition of fuel poverty is intrinsic to successful policy making and policy delivery to fulfill WHECA and eradicate fuel poverty as far as reasonably practicable. However, far from suggesting the definition of fuel poverty is therefore irrelevant, this could suggest there is a weakness in the way the current indicator is constructed. The interim report suggested using median required fuel costs, adjusted for household size and composition, as the "reasonable" energy cost threshold. The income threshold is based on the conventional definition of relative income poverty: 60% of median income after housing costs. Importantly it adds the modeling fuel costs to this threshold, which means that the combined thresholds count a household as fuel poor if it is below the conventional income poverty line and has energy costs above the threshold: Put simply, setting the income and reasonable cost thresholds as described above would mean that households would be considered fuel poor where they had required fuel costs that were above the median level; and were they to spend that amount, they would be left with a residual income below the official poverty line.

The final Hills report concluded that the trends it reports do not reflect well those in the underlying problems, and its definition can encompass households that clearly are not poor. Part of the difficulty is that while a single indicator, it attempts to reflect both the extent and depth of the problem (Hills, 2012).

2.6.2 A new indicator of fuel poverty (LIHC)

In his final report, Hills has therefore retained the suggestion of a Low Income High Costs (LIHC) indicator with only relatively minor definitional changes (Hills, 2012). This new indicator finds a household to be fuel poor if:

- The income is below the poverty line (taking into account energy costs); and
- The energy costs are higher than the typical for their household type.

It also uses a fuel poverty gap. This is the difference between a household's modeled bill and what their bill would need to be to avoid fuel poverty. The purpose of the fuel poverty gap is to measure the severity of the problem faced by fuel poor households. Under this new approach there are twin indicators of the "extent" and "depth" of fuel poverty.

Concurrently, the number of households is relatively stable in the face of changes in energy prices – although as prices rise, the number of fuel poor households increases unless there are other improvements (for example to incomes or energy efficiency standards). The fuel poverty gap is relatively sensitive to changes in energy prices – this reveals how upward pressure on bills deepens the hardship already experienced by fuel poor households.

As well as more accurately measuring the number of fuel poor households, the new indicator (through the fuel poverty gap) allows to identify those who are suffering the most severe fuel poverty. The new LIHC indicator of fuel poverty finds 2.5 million households in England to be fuel poor in 2010, with a total fuel poverty gap of £1 billion or £405 per household in fuel poverty.

Putting in place a new framework for measuring fuel poverty inevitably means some changes to the types of households and people who are found to be fuel poor. For example, many households on a higher income are no longer captured. In addition, some low income households, who would previously have been captured under the 10% indicator, no longer are.

According to LIHC new indicator, a household is defined as fuel poor if its income is less than 60% of the median equivalised income (after housing costs) plus energy expenditure, and if the amount it needs to spend on fuel to maintain an adequate level of energy service is greater than the median equivalised energy bill in the population. In the simplest terms, the household needs to be below the poverty line, and be in that half of the population facing the highest energy costs (i.e. needs to be paying more for its energy than the median energy bill).

2.6.3 Using LIHC to improve targeting

In building the evidence base there has been developed a model to estimate the impact that particular household and dwelling characteristics have on the likelihood of a given household being defined as fuel poor under the new indicator. The model uses logistic regressions to isolate the extent to which different factors change the probability of households living in fuel poverty (Boardman, 2001). The ability to predict the likelihood of being fuel poor in this way opens up the possibility of constructing a tool that could help identify fuel poor households more easily. For example, using a questionnaire with just a few basic questions it would be possible to build a picture of the household circumstances and to calculate the probability of a household being fuel poor.

Whilst this will still result in a degree of uncertainty about whether the household is fuel poor, it potentially offers the prospect of improved targeting compared to current methods. In a future where a strategic approach for tackling fuel poverty is driven by a principle of prioritization, the expected data matching will continue to be important. The success of regulated data matching for the Warm Home Discount (WHD) Core Group and the voluntary agreement underpinning the Affordable Warmth referrals system, highlights the key role that data plays in identifying the fuel poor and targeting support at them.

The scope for increasing the use of automated data matching will be considered. Alongside the role of data sharing in the developing will be taken under consideration as well, a more diffuse delivery landscape. However, there are a number of important factors to consider ahead of making greater use of data-sharing in delivery. These include:

- the need for new primary legislation in order to create a "statutory gateway" for the sharing of personal data;
- changes to the benefits regime which may impact on how well benefit receipt remains a valid proxy for fuel poverty;
- the greater fluidity of the working age caseload compared to that of pensioners who are more likely to remain on low-income benefits;
- the requirement for a guaranteed funding stream to ensure that all matched households can receive a guaranteed benefit; and
- the impact of access to wider "passported" support on incentives to work and save.

2.6.4 Differences between the two definitions of fuel poverty

The 10% indicator measures fuel poverty as a need to spend more than 10% of household income to fulfill reasonable heating and cooking fuel requirements. The LIHC indicator is the official fuel poverty indicator and classes a household as being in fuel poverty if its energy costs are above the average (median) for its household type and this expenditure pushes it below the poverty line. From 2014, national government policy, strategy and programs will be based on the LIHC measure. The main distinction between this and the original definition is that the new definition uses a relative measure of fuel poverty.

The new indicator has been used to help to isolate the impact that particular characteristics have the likelihood of a household being in fuel poverty or severe fuel poverty (which, for the purpose of our analysis, we define as the one-third of fuel poor households with the highest fuel poverty gaps).

As it would be expected, characteristics that drive high modeled energy costs (e.g. having a large, poorly-insulated dwelling with an inefficient heating system) and low incomes increase the

likelihood of a household being fuel poor. The analysis suggests that the size and age of a dwelling and the use of a fuel other than gas to heat the home are strongly associated with fuel poverty.
Many of the same characteristics are associated with households in severe fuel poverty. However, the analysis demonstrates that some of these characteristics – particularly the age and size of the property – are very strongly related to severe fuel poverty. This means that many of the most severely fuel poor households are living in larger dwellings with solid walls.

Table 2.4: *Fuel poverty in England from 2003-2013 under both definitions* (UK Fuel Poverty Monitor 2013-2014)

Year	10% definition (000s)	LIHC definition (000s)	Fuel poverty gap (£m)
2003	1.222	2.441	606
2004	1.236	2.492	644
2005	1.529	2.428	752
2006	2.432	2.262	886
2007	2.823	2.357	904
2008	3.335	2.438	957
2009	3.964	2.486	1.060
2010	3.536	2.474	1.024
2011	3.202	2.390	1.047
2012	n/a	n/a	n/a
2013	5.109*	2.800*	1.200

*Figures for 2012 and 2013 are not official fuel poverty figures and are based on the assumptions from other parties which extrapolates the incidence of fuel poverty from a combination of official statistics and subsequent movements in energy prices.

The fact that the LIHC indicator captures a significant number of large dwellings raises the issue of under occupation. The tendency of the LIHC indicator to capture larger dwellings means that many low income households where the property is "excessively sized" for the number of occupants will be fuel poor. However, the evidence suggests that the size of the property is one of the most important factors in driving high energy costs and, as such, it is our view that a focus on larger properties is appropriate.

In addition to helping us identify the depth of fuel poverty, the LIHC indicator draws a clear distinction between fuel poverty and income poverty. Low Income Low Cost households (LILC) tend to be smaller, more energy efficient dwellings, facing lower energy costs than LIHC households. It is widespread that these LILC households are not the households that should initially be prioritized for support. This is not to say that LILC households will be unable to access support through Government policies.

2.7 Research in the area of fuel poverty

Fuel poverty has moved up the political agenda in recent years with the publication of the UK Fuel Poverty Strategy (2001) (Shortt and Rugkasa, 2005), the Northern Ireland fuel poverty strategy (2004) and more recently the 2005 Labour election manifesto stating that *"by 2010 we will ensure that all social tenants benefit from a decent, warm home with modern facilities"* (Labour, 2005). In Northern Ireland the manifesto from the Social and Democratic Labour Party (SDLP, 2005) stated that tackling fuel poverty *"is not just a social justice imperative but a sound economic investment"*.

Currently, 203,000 families, representing 33% of households in Northern Ireland, live in fuel poverty (NEA, 2004). This level is significantly higher than that experienced in most of the UK and it is estimated that 13% of households in Scotland, 9% in England and 31% in Wales live in fuel poverty. It could be argued that this particularly high figure in Northern Ireland relates to the lack of an adequate gas network and other associated factors contributing to the fact that fuel bills are an estimated 27% higher than in the rest of the UK (CSE/NRFC, 2001). High levels of owner occupation, coupled with low levels of energy efficiency, the aforementioned lack of access to a gas network, lower average income and the relative disadvantage of the entire region make tackling fuel poverty particularly complex.

CHAPTER 3: Fuel poverty in European countries

3.1 Fuel poverty in UK

3.1.1 The differentiating factors among UK regions concerning fuel poverty statistics

Fuel Poverty is a devolved measurement, with each separate administration of the UK having their own policy targets, measurement and outputs. The main reason for the devolution is that the devolved administrations have the power to affect certain aspects of fuel poverty policies (such as energy efficiency programs) but not others (incomes and market conditions, which impact on fuel prices). There are some other differences in the way different countries model fuel poverty, and the frequency and timing of output statistics.

Fuel poverty in England is researched with the EHS; in Scotland, by the Scottish House Condition Survey (SHCS); the Living-in-Wales Survey is used to estimate fuel poverty in Wales; finally, the Northern Ireland House Condition Survey is used to calculate the Northern Ireland fuel poverty levels. There is also the National Ecosystem Assessment (NEA), which is the UK's leading fuel poverty charity campaigning for affordable warmth. Finally, a European project called EPEE aims to improve the knowledge of fuel poverty and identify operational mechanisms to fight against this phenomenon (DECC, 2010).

Table 3.1: *Number and proportion of fuel poor households by country* (DECC, 2013)

Country	Number (millions)	Percentage (%)	Year of estimate
England	3.20	15	2011
Scotland	0.58	25	2011
Wales	0.37	29	2011
Northern Ireland	0.29	42	2011

3.1.2 Surveys held in UK

In a survey of energy efficient British households, it was shown that fuel poverty is a complex socio-technical problem that may be explained using a combination of physical, demographic and behavioral characteristics of a residence and its occupants (Kelly, 2011). A Structural Equation Model (SEM) was introduced to calculate the magnitude and significance of explanatory variables on dwelling energy consumption. Using the EHCS consisting of 2531 unique cases, the main drivers behind residential energy consumption were found to be: number of household occupants, floor area, household income, dwelling efficiency (determined by the

Standard Assessment Procedure (SAP)), household heating patterns and living room temperature. The number of occupants living in a dwelling was shown to have the largest magnitude of effect, floor area and household income while there is strong mediation between causal variables. Statistical analysis implied that homes with a propensity to consume more energy will be more expensive to decarbonize due to the law of diminish- ing returns, a finding of concern in the context of global climate change.

In another UK study, strategies of low-income households for coping with limited financial resources and cold homes in the winter months were investigated (Anderson et al., 2012). The sample of 699 households with an income below 60% of the national median income included in-depth interviews of a subsample of 50 households. Findings showed that the primary strategy adopted by low-income households to cope with financial pressure was to reduce spending, including spending on essentials such as food and fuel. Just below two out of every three (63%) of low-income households had cut their energy consumption in the previous winter and almost half (47%) had experienced cold homes. Very low income households could not afford any heating. For households surviving on very small domestic budgets, it is a sad truth that the extra cash-in-hand could be more attractive than a warmer home.

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". A survey conducted in Ireland noted that existing households needed more fuel than others either because their circumstances imposed that they be heated for longer periods of time or because they were occupied by the elderly or those with very young children so they demanded higher temperatures (Healy and Clinch, 2004) . Households were investigated based on demographic, educational and socioeconomic variables. A very strong relationship was found between the incidence of fuel poverty and social class. As expected, there was a very strong correlation between fuel poverty and income. Results regarding the severity of fuel poverty by income level were mixed, as they revealed both high- and low-income households suffering from high levels of chronic fuel poverty (Whyley & Callender, 1997). Many large families find it difficult to heat their home adequately over time, a troublesome result as health effects of cold and damp exposure are particularly intense among children. It was also found that housing tenure gave households varying levels of control over their home, heating systems and their energy consumption and was identified as an important dynamic of fuel poverty.

Table 3.2: *Fuel poverty levels in the UK by region, 2011* (DECC, 2012a)

Country	**Number of households (millions)**	**% of households**	**Total households (millions)**
England (10% definition)	3.2	15%	21.6
England (LIHC definition)	2.3	11%	21.6
Scotland	0.58	25%	2.3
Wales	0.27	29%	1.268
Northern Ireland	0.29	42%	0.701
UK (10% definition)	4.34	c. 17%	25.86

The Table 3.2 shows that in 2011 the number of fuel- poor households in the Uk fell in 2011 and was estimated at around 4.34 million, representing around 17% of all UK households. Fuel poverty levels in the UK in 2012 and 2013 have yet to be released and are still unclear. In the absence of actual official survey-based UK statistics, fuel poverty researchers are reliant on modelling assumptions from other parties which extrapolates the incidence of fuel poverty from a combination of official statistics and subsequent movements in energy prices. These are only as reliable as the data that underpins them but these estimates for the last two years for Great Britain are included in the following Table 3.3.

Table 3.3: *Fuel poverty levels by region in UK in 2013* (CSE, 2013)

Country	**Number of households (millions)**	**% of households**	**Not fuel poor**
England (10% definition)	5.10	23.7%	16.490.614
England (LIHC definition)	2.79	13.0%	18.800.197
Scotland	1.11	47.7%	1.218.425
Wales	0.52	41.0%	747.919
Great Britain (10% definition)	6.74	c. 26%	18.45 million

One of the key factors driving the increases in fuel poverty based on the 10% definition is the continuing rise in the price of domestic energy. Whilst no UK-wide projections were released alongside the last set of UK-wide statistics, the Westminster Government estimated that price rises in the latter part of 2011 would have led to an increase of around 0.4 m households in fuel poverty in 2012 in England. This results in 3.900.000 fuel - poor households in England in 2012, 28.5% of all households.

3.2 Factors contributing to the current levels of fuel poverty in UK

Whether a household is in fuel poverty is determined by the interplay across four factors: The energy inefficiency of the housing stock, low income, fuel prices and under occupancy.

3.2.1 Energy inefficiency - The Standard Assessment Procedure (SAP) rating

The most significant factor influencing the extent of fuel poverty in the UK and the excess winter mortality has been identified as the poor energy efficiency of the housing stock (Boardman, 1998). Thus, one of the most effective ways of reducing fuel poverty is by improvements in energy efficiency.

The SAP is adopted by Government as the UK methodology for calculating the energy performance of dwellings. The SAP rating is based on the energy costs associated with space heating, water heating, ventilation and lighting, less cost savings from energy generation technologies. It is adjusted for floor area so that it is essentially independent of dwelling size for a given built form. The SAP rating is expressed on a scale of 1 to 100, the higher the number the lower the running costs or better the higher the rating, the more energy efficient the property.

The calculation is based on the energy balance taking into account a range of factors that contribute to energy efficiency (SAP, 2012):

- materials used for construction of the dwelling
- thermal insulation of the building fabric
- air leakage ventilation characteristics of the dwelling, and ventilation equipment
- efficiency and control of the heating system(s)
- solar gains through openings of the dwelling
- the fuel used to provide space and water heating, ventilation and lighting
- energy for space cooling, if applicable
- renewable energy technologies

Housing built today will typically achieve ratings above 70. The statistics given in the Fuel Poverty Strategy (DECC, 2011) indicate the poor energy efficiency of the British housing. The average SAP rating for the stock in 1998 was 44.9 and for the lowest 30% income group it was 42.9. Furthermore, low income households are likely to occupy the least efficient housing. In the UK in 2000 it was estimated that 36% of the housing stock could be designated as "hard to heat". These include those with solid walls, those of non-traditional construction type and those off the gas network. Most of these houses have SAP ratings well below average.

3.2.2 Low income

It is low income combined with poor energy efficiency which results in fuel poverty. Thus, the lower the household income the more likely it is to be suffering from fuel poverty. Low income households are often those who need to spend the highest amounts on energy to keep warm. The government suggests that pensioner households with the Minimum Income Guarantee (MIG) level and families not in paid employment will not be fuel poor if their total fuel bills are around £500 per year assuming the property has good insulation and an efficient central heating system (DTI, 2003). Tackling poverty and social exclusion are key factors in reducing fuel poverty. There are a number of measures identified by the government in its fuel poverty strategy designed to improve income including New Deal, national minimum wage, minimum income guarantee and the various tax credits.

In addition, there are also personal subsidies from the social security fund, providing one off payments for vulnerable households most likely to suffer in cold weather. These include cold weather payments (£8.50 each week of cold weather) and winter fuel payments for pensioners (currently £200). The Department of Trade and Industry (DTI) Select Committee has recommended that the winter fuel payment should be extended to other vulnerable groups (DTI, 2002). The problem with this approach is that payments are only made in severe weather conditions and are paid after expense that may or may not have already been incurred. Households will still not necessarily use this additional income to purchase expensive warmth particularly, as has already been noted that the poor tend to live in housing with the worst SAP ratings.

3.2.3 Fuel price

Over the past 10 years the price of fuel has reduced by 23% in real terms due to the liberalization of the energy markets and the promotion of competition. This has given consumers more choice in who supplies their fuel with the result that customers have been able to switch to cheaper suppliers. It is also suggested that there is little significant class difference in those who switch. However, the consumers who have benefited the most from the liberalization of the energy markets are not generally the fuel poor. Low income householders often have difficulties paying their bills and do not have access to a bank account. They may have to use prepayment meters for their fuel, which usually incurs a higher unit tariff and standing charge than fuel paid for by direct debit. The use of prepayment card meters has increased over the past 10 years and whilst it has actually reduced the number of direct disconnections it has been criticized for increasing the level of self-disconnection and for fuel costs, particularly where it is being used to pay back previous debt. Fuel prices are now set to rise; gas by 5% and this will have an impact on the numbers of fuel poor. The government suggests that a 15% increase in gas prices and a 5% increase in electricity prices could increase the number of fuel poor by nearly one million (DECC, 2011).

More flexible arrangements for the payment of fuel costs have been recommended in Office of the Gas and Electricity Markets (Ofgem)'s Social Action Plan, which has the following key elements (Ofgem, 2008):

- Improve protection for disadvantaged customers through flexible payments, codes of practice for prepayment customers, promotion of help in energy efficiency measures.
- Research into payment patterns
- Downward pressure on prices including the annual surcharge to prepayment customers, now fixed at £15.
- Support for energy efficiency measures through administration of the Energy Efficiency Commitment.

3.2.4 Under occupancy

The size of the property with respect to household size is another factor, which can affect fuel poverty. Those households in the most extreme fuel poverty tend to occupy larger than average houses. In 1998, 1.25 million fuel poor households were under occupying. 67% were in single person households and 70% were households containing pensioners (DTI, 2003). A number of social landlords have incentive schemes designed to assist single households in moving to more appropriate accommodation. Local authorities are now required in their Housing Strategy to demonstrate that they have assessed the extent of the problem.

In order for the issue of fuel poverty to be tackled by governments, it must first accept that the problem is of sufficient political importance to warrant intervention. In this respect there has been significant progress since the 1980s. In 1985 the Conservative government denied the existence of fuel poverty suggesting it was a term with little usefulness. However, by 1997 the Labour government recognized the importance of eliminating fuel poverty and reducing the unacceptable excess winter mortality rates in Britain. Thus, the UK Fuel Poverty Strategy was published in November 2001 (DECC, 2011). There had been a number of initiatives prior to the publication of the strategy mainly emphasizing the need to improve the energy efficiency of the current housing stock.

3.3 Literature review fuel poverty in France

The definition of fuel poverty used at the stage was inspired by the UK definition, but the estimation of the number of households in fuel poverty was based on actual energy expenditures. In France there is a recent fuel poverty policy “Habiter mieux” which has chosen to focus on homeowners living in rural areas and especially on elderly people (Dubois, 2012). “Habiter mieux” aims at improving the thermal efficiency of homes of fuel poor households by 25% at least. It started in 2011. The last national survey was held in 2006, since then France has not collected systematic data on fuel poverty. Habiter mieux is one of the programs selected by future investments and entrusted by L’ Agence nationale de l’ habitat (Anah). This ambitious program helps 30.000 households to improve their thermal efficiency in rural areas. The program “habiter mieux” is a financial and personal support which started in 2011 in France to help poor households to achieve the thermal efficiency needed to reduce their energy consumption by 25%.

Fuel poverty is called “precarite energetique” in France and although it started later than the UK it has been developed in a rapid way with rising energy prices to have become a constant issue in the media since 2004. A network of academics called RAPPEL searched about fuel poverty in France and together with the EPEE published their results using a combination of EU-SILC data and national data. However, the 6% of households suffered from fuel poverty was not definite because there was a lack of extensive data. In 2009, another group under the supervision of the French government, searched about French households in fuel poverty and the published results showed that the problem of fuel poverty in France was seriously affecting 3.4 million households.

Since the RAPPEL has published reports with extensive data, fuel poverty has been introduced into French legislation asking for policies to deal with it. RAPPEL claims that in 2012 more than 3.8 million households in France, which means 14.4% of the population, were fuel poor.
The first measures towards low income households in France which are fuel poor, were developed in the middle of 1980s (Dubois, 2012). However, only in 2010 the current fuel poverty policy was created. The basis of a program is called “habiter mieux” which supports the thermal renovation of

low income households. The aim of 300.000 households to be thermal renovated until 2017 by a financial support from a budget of 750 million euros managed by Anah. This French policy has been based on the low income French households that spend more than 10% over their incomes in order to have their homes adequately heated. A house can be benefited from the program “habiter mieux” if it has a project of thermal renovation of is home that would result in an improvement of at least 25% of the energy sufficiency.

3.4 Literature review fuel poverty in Germany

Rehdanz (2007) presents the results of a survey on more than 12.000 households in Germany for the years 1998-2003. After having analyzed and estimated the results, Rehdanz concludes that household expenditure is much lower for owner occupied households. This might have happened, because home owners have invested for adequate heating and hot water supply systems. On the other hand, tenants suffer from lack of heating as they don’t have control over home improvement and landlords don’t possess any incentive to proceed to improvements to the conditions of their rented houses. The paper also claims that there is no information on age or efficiency of heating systems, installed or about green electricity providers in Germany and because of the different energy prices in Germany regions there should be a future research.

Also there has been showed it is important to realize the energy-related behavior of East and West German households (Braun, 2010). The determinants of the space heating technology are dependent on three sets of variables: building, socio-economic and regional characteristics. This paper supports that the socio-economic characteristics together with the type of building and region are important determinants of the space heating technology applied. The empirical studies revealed social approaches such as price changes, or fuel poverty affect a society as a whole and influence both landlords and tenants.

Braun (2010) analyzed the determinants of the type of Residential Heating Systems (RHS) applied by a household (e.g. the adoption decision itself was not addressed) for a sample of homeowners only a sample including all households (e.g. owners and tenants) based on Socio-Economic Panel (SOEP) data. For Germany, Schuler et al. (2000) investigated the influence of socio-demographic variables on the consumption behavior regarding different types of fuel for residential heating and given building features. Rehdanz (2007), studied the conditional energy demand for space and water heating in Germany (e.g. RHS choice was not explicitly considered) by applying SOEP data.

In this paper also there were presented the preferences of home owners for applying improved RHS. The survey done in Germany showed that the incentives for adopting RHS vary among homeowners. Moreover, the ones that use gas and oil for heating strongly prefer energy savings whereas the ones using heat pumps or wood-pellet fired boilers prefer to be independent from fossil fuels. However, the homeowners of newly built dwellings often have a dilemma either to choose between a basement or a floor heating construction. The data also notified that the grant from the Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA), which would be important for the adoption of RHS doesn't play any role in the decision-making process. Furthermore, in Germany RHS manufacturers should improve their policies in marketing for the homeowners to take the adoption decision, having in mind the variety of not only the behavior of homeowners, but of homes considering their age, and their energy standard or size, as well.

3.5 Literature review fuel poverty in other European countries

Statistical data around Europe has shown that fuel poverty reaches high levels in the South of Europe and according to moderate calculations accounts for about 12%of the households in Italy, 30% in Greece, 26% in Spain and 44% in Portugal. Simultaneously, fuel poverty in England alone totals between 2.8 million and 3.9 million households. In Ireland, estimations show that 17.6% of the households are energy poor, around 226,000 houses. About 27% of the fuel poor houses, around 4.7% of the total housing stock, are suffering from chronic fuel poverty. Also, 12.7% of the households suffer from intermittent levels of fuel poverty, i.e. occupants are occasionally unable to heat their homes.

In Austria, the NELA project (German acronym for "Sustainable Energy Consumption and Lifestyles in Poor and at- Risk-of-Poverty Households") investigated energy consumption in households in Vienna, Austria (Brunner et al., 2011). NELA surveyed 50 Viennese households afflicted by poverty and compared them to ten better - off households. The interviews were conducted during the summer of 2009 and the spring of 2010.The results identified four distinct types of households: "the overcharged", "the modest fuel poor" (fuel poor), "the modest non-fuel poor", and the ones "on a low income" (non-fuel poor). Similar classifications were found by a survey conducted in France by Devaliere (2010) as quoted by Brunner et al. (2011). It was confirmed that low income households try to cope by adopting various energy conservation measures.

Buzar (2007) claims that fuel poverty is apparent in post socialist countries of Eastern and Central Europe and the Former Soviet Union. The author mentions to the "hidden" geography of poverty, referring to the lack of heating in the households of these countries. A survey held in Former Yugoslav Republic of Macedonia (FYROM) and the Czech Republic showed that low income households are energy poor and areas of energy poverty (called "hidden") appear dull and messy due to specific circumstances of the post-socialist frame of these regions.

Turning to Southern Europe, in Italy, the E-SDOB (Statistical Distribution of Buildings) tried to address heating energy issues by defining the performance scale for energy certification of buildings, and evaluating the building volume falling in different classes (Fracastoroa and Serraino, 2010). E-SDOB has also been used to evaluate the energy saving potential of large scale retrofit actions on the building envelope. E-SDOB seems to be a useful tool for a better knowledge of the regional building stock as well as the adoption of coherent energy regulations. As the authors point out though, the global overview of the building stock energy performance provided by E-SDOB may provide further insight but it cannot replace specific analyses at a building level when retrofit actions have to be implemented.

In Spain, the Environmental Science Association (Asociación de Ciencias Ambientales, ACA) started a project named REPEX aiming to research the relationship between fuel poverty and unemployment. This project claims that fuel poverty in Spain is caused by unemployment and that the renovation of houses, in order to be efficiently heated, could offer employment to workers that lost their jobs because of the financial crisis. However, fuel poverty in Spain is not a first priority issue either to the Spanish Political Parties or to the media (EU Fuel Poverty Network, 2013).

3.6 Literature review fuel poverty in Greece

Turning to investigations in Greece about the specific energy consumption of households and its relation to the economic situation, a 2004 survey held in Athens, collected social, financial, energy and technical data from about 1110 households (Santamouris et al., 2007a). These households were divided into seven income groups and a detailed analysis showed that there was an almost direct relationship between income and household area. It was also found that higher income was associated with newer buildings and that almost 64% of the families in the lower income group lived in apartments (the corresponding number for the more affluent group was 48%). Low income families lived mostly in the lower part of multistory buildings while high income households live mainly in the higher part of the buildings. Only 28% of people in the poorest group dwelled in insulated buildings, with the corresponding figure for the rich- est group being close to 70%. High income families paid almost 160% higher annual costs than the low income ones. Low income households paid nearly 67% higher electricity cost per person and square meter than high income households. Furthermore 1.63% of the households suffered from fuel poverty and 0.35% from severe fuel poverty (2004 values). Fuel poverty in low income groups, was in the region of 16%. Severe fuel poverty, in the low income group, was calculated close to 4%. Concerning energy poverty, the aver- age percentage of the households spending more than 10% of their income for energy was close to 11.3%, while 2% spent more than 20%. Almost 40% of the low income group, called the energy poor, spent more than 10% of their income for energy while almost one fifth of the poor households, called the severely energy poor, spent more than 20% of their income for energy. Fuel and energy poverty reached quite high levels in the low income groups, with a dramatic increase attributed to the fuel prices. It was concluded that energy policies addressed to the dwelling sector should set as a priority the improvement of the envelope quality of residents where low income people are living.

In another study referring mainly to the summer conditions (Santamouris et al., 2007b), it was found that low income population in Athens, lives in areas where the heat island is well developed. Recent studies have shown that temperature increase in high density areas suffering from heat island may reach 5–7 K, depending on the local climatic conditions (Santamouris, 2007; Livada et al., 2002). Higher urban temperatures increase considerably the necessary energy consumption for cooling purposes (Hassid, et al., 2000; Santamouris et al., 2001) affect thermal comfort conditions (Pantavou et al., 2011) and increase pollution levels (Stathopoulos et al., 2008). Monitoring of a high number of low income households in Athens during the heat waves of 2007 (Sakka et al., 2012) shown that indoor temperatures as high as 40 °C occurred while the average indoor minimum temperature was always above 28 °C.

A study of a typical multi-family Greek building in 2007 com- pared commonly used heating sources (including oil), natural gas and autonomous systems (Papadopoulos et al., 2007). The cost distribution of central heating was determined to favor penthouses over apartments in intermediate floors, possibly failing to motivate some occupants to promote energy conservation while at the same time not providing motivation for superior insulation of the roof of a building. The authors asserted that the use of electrically driven heat pumps can be a very good solution for heating Greek buildings, since (at the time of writing) they were in some cases equally expensive to other fuels. It was also suggested that the increased potential of renewable energy sources in electricity generation (mainly wind power) might also be improved. The authors expected the nationalization of electricity tariffs to enable the installation and use of heat pumps as central heating systems, increasing in turn their market infiltration.

Sardianou (2008) highlighted the use of statistical models in determining domestic consumption of Greek households. The results of the survey held in 2003 in Greece, unveiled that various characteristics such as the number of persons in a household, the type of the building and the ownership status, influence the domestic demand for heating. Findings confirmed that there is a relationship between household annual income and annual fuel consumption while there were already (back then) households that had decreased their heat- ing consumption in view of increasing oil prices.

Finally, according to the most recent opinion survey of fuel poverty in Greece (Panas, 2012), the median specific energy consumption of buildings in Athens was found to equal 29 kWh per cubic meter, greater (the author asserted) than that of other countries with more adverse weather conditions such as Denmark, Germany and the Netherlands. Fuel poverty was calculated with three differ- ent methods based on (a) the proportion of energy expenditures of a household, (b) the opinion of residents on their energy coverage and (c) the condition and conveniences of the household. From 1988 to 1997 Greece was found to have a seasonal rate of mortality of 18%, which ranked it at a position higher than that of other countries with heavier winters. Panas refers to the relation between the inadequate heating of households and the increased mortality rate during the winter season. However, through a recent questionnaire survey in northern Greece conducted in November of 2012, 814 people were asked whether they paid more than 10% of their annual income for heating (it is noted that this is a subjective method of documenting fuel poverty). According to the survey, respondents declared their inability to pay the heating bills and their fear for consequences of the current economic crisis in the future, supporting the notion that Greek households are not presently energy efficient.

Important research has been carried out to develop and pro- pose proper mitigation and adaptation techniques to improve the environmental performance of low income households (Santamouris, 2013; Santamouris & Kolokotsa, 2013). Applications in real scale projects showed that it is possible to improve considerably the environmental quality of buildings and open spaces, decrease the energy consumption and improve the quality of life of low income citizens (Santamouris et al., 2012).

3.6.1 *Financial crisis and energy consumption: A household survey in Greece*

The research of Santamouris et al. (2013), in Greece, investigated, analyzed and characterized the relation between the economic crisis and energy consumption in Greece. A survey held in the spring and summer of 2012 collected data of the heating energy consumption for 2010–2011 and 2011–2012, from 598 households via a questionnaire. Comparing the 2010–11 winter to the harsher winter of 2011–12 showed that inhabitants consumed less energy during the winter of 2011–12 because of the rapid economic degradation. Important conclusions were drawn regarding the energy consumption of the households which during the harsh winter 2011–12 was 37% less than expected. Cluster analysis rendered two distinct clusters: three fourths of the households belonged to the lower income group that lived in a smaller space, had half the income and consumed more specific energy compared to the high income group, although much less than expected based on the degree hours of the second winter. One out of three higher-income and one out of four lower-income households adopted some conservation measures after the first winter while 2% of the higher income households and 14% of the lower-income households were below the fuel poverty threshold.

CHAPTER 4: Energy poverty policy directions

4.1 Fuel poverty in the EU

The definition of the term energy poverty was left up to the Member States of EU, even though it was emphasized that high levels of consumer protection should be ensured, alongside switching to a new supplier and the possible prohibition of disconnection of electricity to such customers in critical times (EP, 2009). The increasing prominence of energy poverty within the EU political sphere is also evidenced by the opinion on Energy poverty in the context of liberalization and the economic crisis, issued by the European Economic and Social Committee (EESC) on the 14th of July 2010. Having concluded that energy poverty affects the energy sector while also impacting health, consumer affairs and housing, the Committee suggested that the EU adopt a common general definition of energy poverty that can then be adapted by each Member State. It furthermore proposed the formation of a pan-European monitoring center that would help establish the extent of energy poverty. This was also the first time when EU institutions recognized the specific nature of the problem: Article 2.7 of the Committee's conclusions identified low incomes, inadequate building quality and high energy prices as the causal factors of energy poverty (Shortt and Rugkasa, 2007).

It was also felt that current policy recommendations are far too general and lacking any practical implications. As a result, the movement towards greater political awareness of energy poverty at the EU scale has amounted to very little direct real-life action at different levels of governance. Not only have the provisions in the Third Energy Package and subsequent documents failed to translate into any mandatory EU-level requirements to deal with energy poverty specifically – other than competition and energy efficiency policies, which are themselves much more indirect – but the EU has even stopped providing a common definition of the problem, which might give it better visibility at the member-state level. The lack of a common approach at the European scale – including the absence of a definition of the term vulnerable consumers – has also prevented the adoption of unified monitoring and evaluation methodologies.

It was pointed out that EU should make efforts to incorporate energy poverty- relevant objectives in the formulation of the new cohesion policy framework, so as to alleviate regional disparities in the provision of energy services. This is of particular importance for new and forthcoming member states, in terms of the improvement of relevant energy infrastructure, housing conditions and most of the work carried out (under the EPEE and other initiatives) looks at the causes and consequences of fuel poverty and best practice to reduce its scale and negative consequences (Bouzarovski et al., 2012).

Table 4.1: *Key milestones in the adoption of energy poverty – relevant policies in the EU* (Bouzarovski et al., 2012)

Date	Event/decision/publication	Recommendations made
7/2009	Gas and electricity liberalization directives	• National governments were asked to formulate 'appropriate measures' to address energy poverty, including the development of national energy action plans. • An 'integrated approach' within the framework of social and energy efficiency policies was suggested to achieve this, in order to allow 'national policies in favor of vulnerable customers'.
7/2010	European Economic and Social Committee opinion on energy liberalization	• Underlined that 'existing statistics should be harmonized so that the most rigorous assessment possible can be made of the energy poverty situation in Europe'. • Insisted that 'it would make sense to set up a European Energy Poverty Monitoring Centre, which could fit within an existing body such as the Agency for the Cooperation of Energy Regulators'.
11/2010	European Commission	• Encouraged 'Member States to adopt appropriate long-term policy solutions, and not only temporary relief' with the aim of replacing 'direct subsidies for high energy bills with a support for improving the energy quality of the dwellings'. • Suggested that energy poverty might be quantified by establishing 'the number or proportion of households struggling to settle their energy bills', those who 'spend more than a pre-defined threshold share of their overall consumption expenditure on energy products' or by focusing on payment difficulties and arrears.

Energy poverty first entered the vocabulary of EU institutions in the process of preparation the Third Energy Package, when political action within the European Parliament led to the integration of energy poverty concerns within the Directives 2009/72/EC and 2009/73/EC of the European Parliament (EP) and of the Council, *"concerning common rules for the internal market in electricity and natural gas supply"* (EP, 2009). The compromise text of the directives recognized the existence of a growing energy poverty problem in Europe, requiring Member States *"who are affected and which have not yet done so' to ensure the necessary energy supply for vulnerable customers, so as to decreasing the number of people suffering from this situation"* (Boardman, 2010).

In the European Fuel Poverty and Energy Efficiency Project Recommendations Guide for policy makers, the authors note the lack of a clear EU definition of fuel poverty, and recommend *"the inability to keep the home adequately warm at an affordable cost"*. They state that fuel poverty derives from a combination of low household income, poor heating and insulation standards, and high energy prices' (EPEE, 2009)

The indicators used to measure fuel poverty are referring to the inability of people to keep their home adequately warm, to pay their utility bills and to live in a dwelling without defects (leakages, damp walls, etc.). In 2012, 10.8% of the total European population were unable to keep their home adequately warm, increasing to 24.4% when referring to low-income people. The table 4.2 below presents the correlation between these indicators, as well as the connection between the indicators and the percentage of people at risk of poverty.

Table 4.2: *Correlation between fuel poverty indicators* (BPIE calculation based on Eurostat data 2012)

	People at risk of poverty	**Inability to keep home adequately warm**	**Dwelling with a leaking roof, damp walls**	**Arrears on bills**
People at risk of poverty	1	0.77	0.23	0.84
Inability to keep home adequately warm	0.77	1	0.29	0.58
Dwelling with a leaking roof, damp walls	0.23	0.29	1	0.32
Arrears on bills	0.84	0.58	0.32	1

There is a strong correlation (0.84) between the percentage of people living at risk of poverty and the percentage of people falling into arrears, which means that countries with the highest percentage of poor people tend to have the highest percentage of people falling into arrears.

Greece, Romania and Bulgaria have the highest percentages of people falling behind on their payments, with Greece showing a huge increase compared to the 2009 share. At the other extreme, in Luxembourg, The Netherlands, Germany and Denmark, the payment of utility bills is a problem for only a small percentage of the total population.

The inability to keep the home adequately warm is one more fuel poverty indicator. As presented in Table 4.2, there is a strong link (0.77) between people at risk of poverty and those who are unable to keep their home adequately warm.

Studying further the fuel poverty indicators across Europe, Bulgaria and Lithuania are the countries with the highest rates of people who are not able to keep their homes adequately warm. These countries are followed by Cyprus, Portugal and Greece, all of which are Mediterranean countries with mild winters. On the contrary, in colder Northern countries (Sweden, Finland, The Netherlands and Denmark), only a low percentage of the total population is unable to have an adequately warm home.

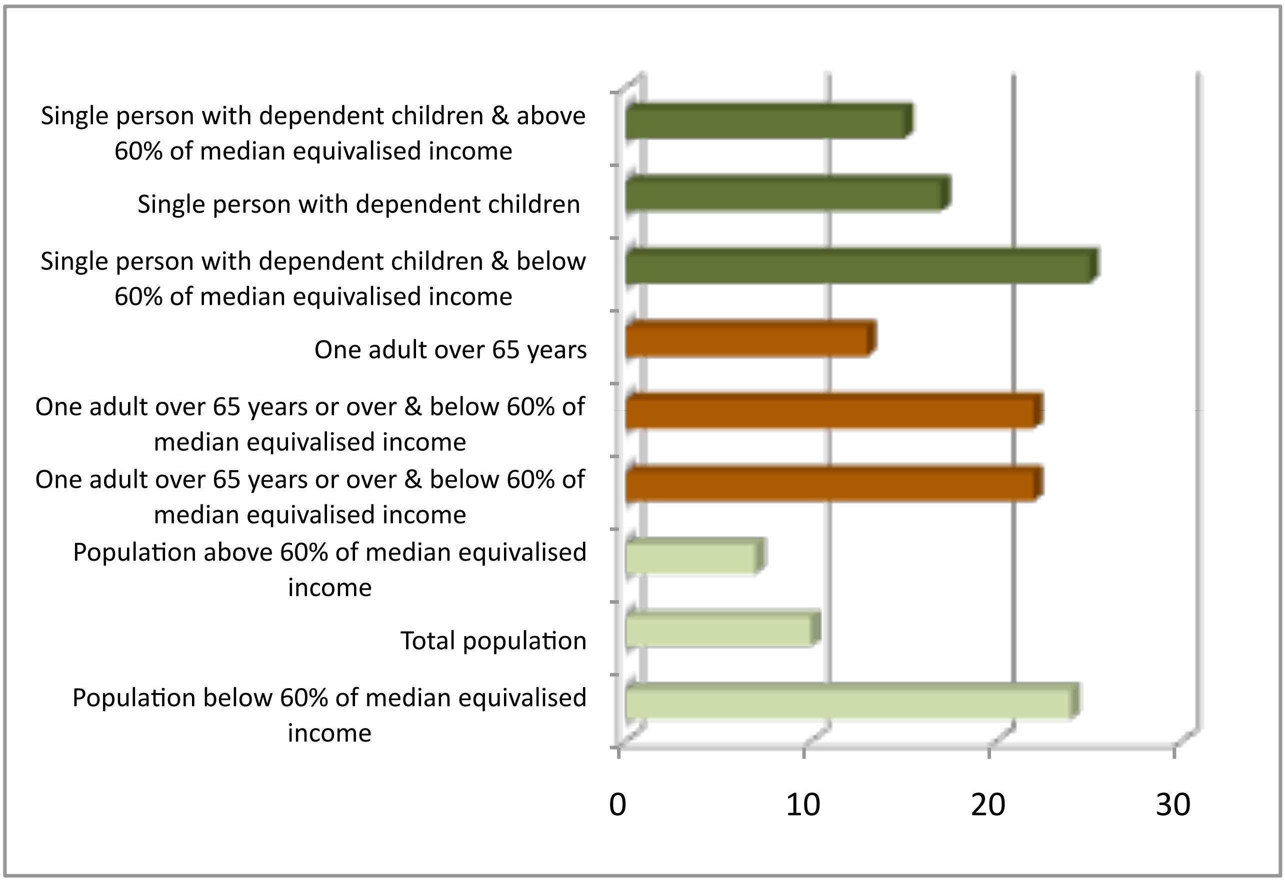

Figure 4.1: *Percentage of different (vulnerable) consumers' categories in the EU that are unable to keep their home adequately warm* (Eurostat data, 2012)

The maintenance of a warm indoor environment is a very challenging task, especially for people at risk of poverty. In 2012, 24.4% of the poor people in Europe cannot afford an adequately warm home, while additionally 8% of people who are not at risk of poverty face the same problem (Figure 4.1). More specifically, 70% of the poor people in Bulgaria were unable to have an adequate warm home, while the corresponding percentage for Cyprus, Greece, Italy and Portugal was above

40% (Figure 4.2). In addition, Romania, Poland, Malta, Latvia and Lithuania also registered higher levels than the EU average.

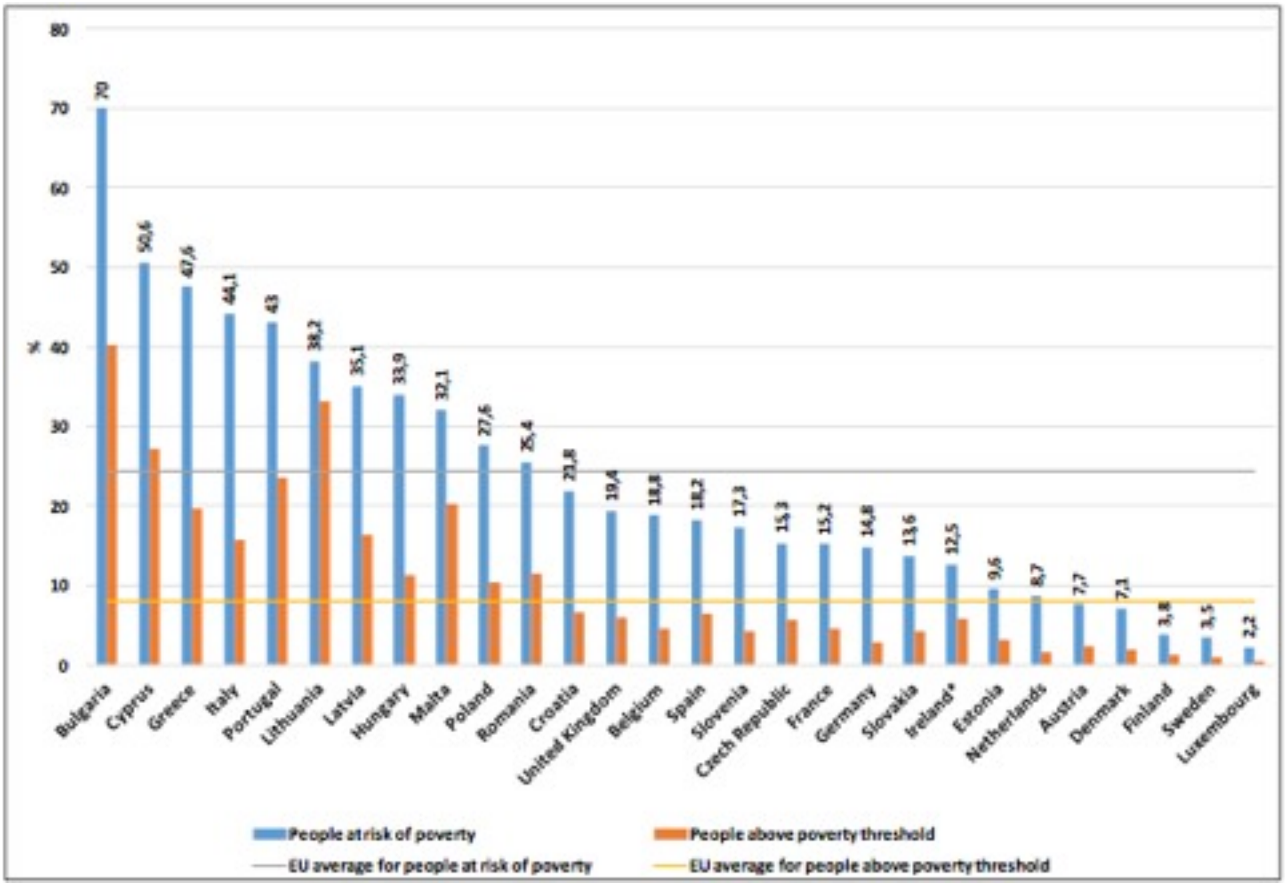

Figure 4.2: *Inability to keep home adequately warm* (Eurostat data, 2012)

The third fuel poverty indicator is the percentage of the population living in a dwelling with a defect, notably a leaking roof or damp walls, floors or foundation. In this category, Slovenia, Cyprus and Latvia show the highest percentages, while in Slovakia, Sweden and Finland less than 9% of the population live in homes with these defects.

The percentages of the aforementioned fuel poverty indicators are significantly high among people at risk of poverty. As shown in Table 4.3 (it shows which EU countries are ranked by the average of the three fuel poverty indicators), high share of people at risk of poverty with particularly high rates in fuel poverty indicators come from the countries from the left side of the table, i.e. Bulgaria, Hungary, Greece, Latvia and Cyprus.

Table 4.3: *Fuel poverty indicators of people at risk of poverty* (Eurostat data, 2012)

Country	Arrears on utility bills (%)	Inability to keep home adequately warm (%)	Dwellings with leakages & damp walls (%)
Bulgaria	50.7	70	29.5
Hungary	58.8	33.9	53
Greece	54.4	47.6	21
Latvia	39.5	35.1	43.3
Cyprus	25.9	50.6	34.6
Slovenia	37.5	17.3	46.1
Italy	24.5	44.1	30.1
Romania	41.5	25.4	30
Lithuania	22.8	38.2	28.6
Portugal	14.5	43	28.4
Croatia	40.9	21.8	19.9
Poland	30.1	27.6	20
Malta	19.4	32.1	12.4
UK	20.3	19.4	21.4
Estonia	20	9.6	30.3
Belgium	14	18.8	26.2
Ireland*	27.5	12.5	16.2
France	17.8	15.2	22.1
Czech Rep.	19.4	15.3	20
Spain	17.9	18.2	17.9
Slovakia	18.3	13.6	19.7
Netherlands	8.6	8.7	27.4
Germany	8.6	14.8	21
Denmark	5.5	7.1	25.3
Luxembourg	6.6	2.2	28.9
Austria	11.3	7.7	15.2
Finland	13.7	3.8	8.6
Sweden	10.3	3.5	11

* Data from 2011

To conclude, fuel poverty is a major threat for a significant proportion of the European population (Table 4.4), though rates vary significantly across different member states. Perhaps it is surprising to note that fuel poverty is less of an issue in colder countries than in warmer ones. Apart from differences in relative income, an explanation can be found in the fact that a colder climate means that energy efficient dwellings become much more of a necessity, with progressively tougher building standards introduced over the years as technologies develop.

Table 4.4: *Average share of poor and fuel poor people (proxy indicators) in the EU28 for 2009 and 2012*

	People at risk of poverty (%)	**Inability to keep home adequately warm (%)**	**Dwelling with a leaking roof, damp walls (%)**	**Arrears on bills (%)**
2009	23.2	9.3	16	8.9
2012	24.8	10.8	15.11	9.7
Relative difference from 2009 to 2012	6.9	17.40	-5.63	8.99

4.2 Examples of institutions documenting the problem of fuel poverty in UK

NEA is the UK's fuel poverty charity campaigning for affordable warmth. NEA is also a member of the Energy Bill Revolution Campaign, an alliance of all over so leading charities and businesses on the Government to use carbon tax revenue to make UK households super-energy efficient. NEA is currently working to exploit the link between preventative public health policy and tackling fuel poverty, and how these objectives could be brought together to provide a strong incentive to act and to track progress through the revised Home Energy Conservation Act (HECA) guidelines (Smith, 2012).

Warm Front Scheme is the government's main grant-funded program for tackling fuel poverty in England to help pay for energy efficiency. EPEE is a co-financed European project by the European Commission Intelligent Energy for Europe program, whose goal is to improve the knowledge and understanding of fuel poverty, evaluate the number of households currently living in fuel poverty in the 5 partner states and identify operational mechanisms to tight against this phenomenon.

NEA has been involved in a project to assess the scale of fuel poverty and how well this issue is understood in a number of European countries. Working in partnership with agencies from the UK, France, Italy, Spain and Belgium in a project known collectively as the EPEE projects, the main purpose of which was to raise the profile of fuel poverty in countries where the issue is barely recognized and to see if a common European approach could be developed in order to define and resolve the problems faced by low-income energy consumers.

4.3 Policy directions for supporting vulnerable households

Fuel poverty policies have historically been targeted at groups of "vulnerable" fuel poor households – in particular, households containing older people, children and long-term sick and disabled people. Vulnerable fuel poor households face the problem of low income and high energy costs. Consequently, they are more likely to suffer negative impacts as a result of their fuel poverty. The vulnerability of certain households will continue to be a factor when prioritizing households for support and when determining how those households should be supported.

In the context of fuel poverty, vulnerability encompasses a range of wellbeing and social issues. The evidence of cause and effect is strongest in the area of health. The evidence suggests that there are a number of health conditions – including cardiovascular and respiratory diseases – that are caused or exacerbated by living in cold conditions. Whilst all types of people can be affected negatively by living in cold homes, the evidence points to the fact that the impacts are most acute for vulnerable households, particularly children and older people. For example, children living in cold homes are significantly more likely to suffer from chest problems, asthma and bronchitis.

The fuel poverty methodology takes some account of the vulnerability status of households by applying a more generous heating regime to people who are likely to spend more time in home (e.g. households containing pensioners, families with young children and long term sick or disabled). This means that these types of household tend to have high energy requirements and are more likely to be classified as fuel poor. However, the LIHC indicator does not capture the fact that these types of vulnerable fuel poor households are more likely to suffer negative health impacts as a result of their fuel poverty. The previous 10% indicator treated vulnerability in the same way.

The fact that certain types of people are more vulnerable to the negative impacts of fuel poverty is an important consideration for fuel poverty policies. In order to consider more thoroughly the impact of cold homes in our policy development, a cooperation with experts took place so as to develop a methodology to estimate and monetise the health impacts of fuel poverty policies (DECC, 2013b).

Fuel poor households can be supported with policies that reduce energy cost (which include policies that increase energy efficiency, encourage switching to better energy tariffs and/or directly support household energy costs) and through policies that increase incomes.

4.4 Fuel Poverty-Marginal Alleviation Cost Curve (FP-MACC)

The aforementioned Hills Review suggested that – based purely on a consideration of subsidy cost – those policies that improve the thermal efficiency of dwellings tend to be more cost effective for addressing fuel poverty compared to policies that are focused on subsidizing energy costs or increasing incomes. This analysis by has been built up by constructing a Fuel Poverty-Marginal Alleviation Cost Curve (FP-MACC) to show the potential and cost-effectiveness of the different options that are available to support fuel poor households. The FP-MACC shows the types of support that should be prioritized in order to drive an improvement in fuel poverty in the lowest cost way.

The analysis shows that there is significant potential for cost-effective measures to support the fuel poor. There are a number of noteworthy aspects:

- *The importance of energy efficiency and conventional heating:* there is significant cost-effective potential for low-cost loft and Cavity-Wall Insulation (CWI) and heating measures. Much of this potential is among severely fuel poor households. In addition, the analysis suggests that there is some cost effective potential for more expensive efficiency measures.
- *The role of renewable heat:* the MACC suggests that there is some potential for supporting fuel poor households through renewable heat – for example, Ground-Source Heat Pumps (GSHP) and Air-Source Heat Pumps (ASHP) – particularly in fuel poor households that are not connected to the gas grid.
- *Energy bill rebates:* in contrast to efficiency measures (which tend to have ongoing benefits to a household) energy bill rebates only have a positive impact on a household in the year in which the rebate is paid. In spite of this, the MACC suggests that rebates are more cost effective than many of the more expensive efficiency and heating options. Furthermore, energy bill rebates are a special case in the MACC as it is possible (in principle at least) to deliver a very large number of energy bill rebates in a given year. This is unlikely to be the case for most energy efficiency and heating measures – where, due to supply constraints, it would tend to take a number of years to deliver all of the available measures to households.

The FP-MACC is a useful tool for guiding policy development. However, it only examines fuel poverty solutions from the perspective of cost effectiveness. While this is an important consideration, there are many other factors that Government must consider when developing policies. For example, the FP-MACC does not give a sense of the practical barriers to the delivery of certain measures (targeting of support, supply chain constraints, etc.). Other evidence is needed in order to help support decisions around delivery approaches.

The impact of the policy package is presented in comparison to a no policies scenario – that is, a scenario where no climate and energy policies are implemented. The projections show that the fuel poverty gap is expected to increase significantly in the 'no policies' projection, from around £1.0 billion in 2010 to around £1.6 billion in 2022. This is largely the result of rising fossil fuel prices (DECC, 2013b).

The projections show that policies are expected to drive a significant reduction in the fuel poverty gap over time. The "with policies" projection suggests that the fuel poverty gap will be reduced by over 20% in 2022 as a result of policies. This equates to an absolute reduction in the fuel poverty gap of around £350 million.

The key factor behind the reduction in the fuel poverty gap (relative to the "no policies" projection) is the improvement in the energy efficiency of dwellings. The estimates suggest that the climate and energy package will increase the average SAP rating of fuel poor households from around 47 in 2010 to around 55 in 2022. (DECC, 2013b)

4.5 Fuel Poverty – policy considerations

Fuel poverty carries a broad range of social implications which need to be addressed by governmental policy if eradication of fuel poverty is to be realized. While the three main drivers of fuel poverty are considered to be low income, high fuel costs and poor energy efficiency of homes, the policy effects can be most readily seen in the fields of health, the built environment and social policy.

4.5.1 The health effects of fuel poverty

It is recognized that appropriate indoor temperatures vary depending on the individual's age, mobility, and overall health and wellbeing. Wider evidence gathered over the last 40 years suggests that indoor temperatures that are too cold (below 18^{o}C) and too hot (above 24^{o}C) can damage physical and mental health, reinforcing the need for a year round seasonal approach to health morbidity and mortality (Walker et al., 2013).

The impact on health and wellbeing and health inequalities of wider determinants such as income, housing and employment are well established in research and policy. Greater alignment of health and environmental agendas, together with an increased focus on preventing ill-health, are critical for addressing health inequalities.

Table 4.5: *The effect on comfort and health of exposure to varying living room temperatures* (FPV, 2003)

Indoor temperature	Effect
21°C	Comfortable temperature for all, including older people, in living rooms during the day.
18°C	Minimum recommended night-time temperature for those with no health risk, although older and sedentary people may feel cold.
Below 16°C	Resistance to respiratory diseases may be diminished.
9-12°C	Exposure to temperatures between 9°C and 12°C for more than two hours causes core body temperature to drop, blood pressure to rise and increased risk of cardiovascular disease.
5°C	Significant increase in the risk of hypothermia.

The relationship between poor quality housing and ill health is well established and the subject has been extensively reviewed. Indeed the catalyst for state intervention in housing in the mid 19th century, resulting in the "sanitation" of the environment was the impact of poor housing conditions on the health of the working class population (Shenton, 2002). Early pioneers such as Chadwick and Snow demonstrated the significance of these conditions on health and persuaded the government of the time to introduce the first public health acts in Britain in 1848 and 1875. This intervention had a much more profound effect on improving public health than any subsequent medical intervention, by increasing life expectancy and reducing infant mortality rates. It was, therefore, no coincidence that the responsibility for housing policy was initially under the direction of the Ministry for Health and this remained the case until 1951. The divorce of housing and health policy took place when the responsibility for housing was transferred to the then Ministry for Housing and Local Government. Ever since then the justification for state intervention in housing policy on health grounds has been severely limited. Indeed successive British governments have been criticized for failing to recognize the significance of the health benefits of good housing, particularly in respect to reducing inequalities in health.

During the 1980s and 1990s, a major research effort attempted to re-establish the link between poor housing and ill health to persuade the government of the advantages of increased housing expenditure. This research, however, often failed to demonstrate causation, the difficulty being an inability to isolate housing condition from other factors such as poverty and deprivation.

Despite this, many researchers were able to demonstrate that poor housing influenced health status often by increasing the susceptibility of occupiers to a variety of health hazards even though it might not directly cause ill health. However, some academics have suggested that this obsession with proving causality is ill founded (Allen, 2000; Boardman, 2010).

Evidence of a link between fuel poverty and ill health has been well documented (Boardman, 1993; CSE, 2001; Wilkinson et al., 2001; Lawlor, 2001; Donaldson and Keatinge, 2002). The effects on health can generally be divided into two categories: *the impacts of low internal temperatures and dampness and mould growth.* The excess winter mortality rate in UK is estimated at between 30.000 – 60.000 each year (Boardman, 1993;Wilkinson et al, 2001; Archer, 2002). This excess death rate is one of the worst in Europe; only Ireland is comparable. Other countries such as Norway and Sweden have much smaller death rates of approximately 10% despite having much colder winter temperatures (Khaw and Woodhouse, 1995). In 1998 Donaldson et al. concluded that Britain had worse excess deaths than Siberia. Many of these cold related deaths are entirely avoidable. Deaths occur in all age groups, although rarely in the 5-24 age group (Curwen, 1981). It is also worth pointing out that a bad winter does not necessarily cause the deaths of those who would have died if there had been no risk associated with cold weather (Curwen and Devis, 1988). There is also a marked social class gradient in excess winter mortality according to Curwen, (1981). In 1985 the then Chief Medical Statistician suggested that for *"every degree change in the average winter temperature there is a rise or fall in the number of winter deaths of 8.000"* (Alderson, 1985). Curwen, (1991) has estimated that one third of the "excess winter deaths" are attributable to respiratory disease and over half to heart attack and stroke. Hypothermia is registered as a cause in only 1% of the total deaths throughout the year (Collins, 1983). There is some controversy over the precise cause of the excess winter deaths in Britain. However, there is general agreement that temperature is the key factor as suggested by Alderson (1985). According to Keatinge (1986) there may be some issues regarding the relative contributions of internal and external temperatures. If external temperatures are a factor then there is a need to educate the public about appropriate clothing. The Eurowinter Group, 1997 suggests that excess winter deaths are lower in other European countries because their housing is more energy efficient and people dress up warmer to go out.

As well as excess mortality rates during the winter months there is also a considerable increase in morbidity rates. Cold housing is often associated with dampness and mould growth. Mould and mould spores are associated with a wide range of detrimental health effects such as asthma and other allergic diseases (Platt et al. 1993; Raw et al, 2001). Cold, damp housing also affects the mental health of the fuel poor according to a study carried out in London and in particular leads to stress related to the payment of fuel bills. House dust mites also proliferate in cold, damp housing and there is evidence of a link to asthma (Raw et al, 2001) and perennial rhinitis and eczema (Howarth et al, 1992). Thus, there is little doubt about the contribution that cold housing plays in excess winter mortality rates in UK.

4.5.2 Working towards a most efficiency support for vulnerable householders

Defra (2004) is committed to shielding the needs of rural communities, ensuring that more fuel poor in rural areas are able to receive support through government policies. Many of the fuel poor in rural areas live in hard to heat properties with higher fuel costs, as shown through the higher fuel poverty gap of rural fuel poor households - £588 against an average gap of £404 for all households and £361 for urban households. Defra supports the network of Rural Community Councils (RCC), who play an important role at the local community level for example through awareness raising and encouraging fuel clubs that can reduce costs through bulk purchases (DECC, 2013b).

Through the Cold Weather Plan, the Department of Health has developed guidance to help to reduce the number of excess winter deaths that occur each year. The 2012 plan sets out a series of steps for organizations and individuals to reduce the risks associated with extreme cold weather. Future action is likely to be led by Public Health England.

In addition, the National Institute for Health and Clinical Excellence (NICE) is developing guidance aimed at preventing excess winter death amongst vulnerable people. This will provide recommendations for best practice for practitioners in public health. Publication of the final guidance is scheduled to be in 2015 (DECC, 2013b).

Under new legal duties contained in the Health and Social Care Act 2012, National Health Service (NHS) England and each clinical commissioning group must take under consideration the need to reduce inequalities in access to health services and the outcomes achieved for patients. They will also be under a duty to provide services in an integrated way, where they consider that this would reduce inequalities in access to those services or the outcomes achieved. Tackling health inequalities is also a priority for Health and Wellbeing Boards led by local government as part of their new public health responsibilities. The 2012 Act imposes a duty on NHS England and clinical commissioning groups to encourage integrated working in the provision of health and social care where this would help reduce health inequalities. This provides the framework for cross sectoral working to address the poor health outcomes that are driven by socio-economic factors across society, including fuel poverty (DECC, 2013b).

4.6 Policy directions towards elimination of fuel poverty

4.6.1 Housing and Development

In his analysis of the situation in eastern and central Europe, Buzar defines "energy poverty" as *"the inability to heat the home up to a socially- and materially-necessitated level"* (Buzar, 2007). It is noted that energy poverty can be identified through surveys of wellbeing or patterns of household expenditure, even when information on temperatures and on consumption by individual households is hard to come by. Again, the analysis focuses on the importance of improving the state of the housing stock.

Whilst the strongest motivator for the reduction of fuel poverty is the health implications and associated cost to society, another key area for policy consideration is housing and development. At the current rate of housing demolition it will take around 200 years for a complete turnover of the UK housing stock, so unless a significant increase in redevelopment of housing is realized in the very near future, it is retrofit rather than development that is the only realistic policy option for UK government. The BIG Energy Upgrade is unique in this respect, in that it is the first study to consider all of the above retrofit impacts as well as their fuel poverty reduction effects.

In doing so, the data and outputs created by the BIG Energy Upgrade are of particular importance to the UK government when calculating and modeling the impact of the Green Deal upon society and the EU 2020 targets (Koh et al., 2012b).

4.7 Policies addressing fuel prices

4.7.1 Warm Home Discount

The WHD was introduced in 2011 and is a discount on energy bills provided by major UK energy companies. The policy mainly targets elderly, but can also be applied to other vulnerable groups. It is one of the more recent UK fuel poverty related policies where funds do not come from the government, costs are carried by energy companies who pass it on to other consumers (Hills 2012). The WHD has been criticized because certain vulnerable groups (e.g. large families) are not eligible (Consumer Focus 2011). Also, Baker (2007) points out that social tariffs only work if there is price transparency, and points out that in some cases social tariffs are not the best option for a household.

4.8 Energy efficiency programs

A fuel poor household is defined as one whose members would need to spend more than 10% of their income in order to achieve a satisfactory heating regime (in line with World Health Organization recommendations), and to meet other energy needs (Boardman, 1991). The strength of the definition, in policy terms, lies in the way in which it points to the most durable way of alleviating fuel poverty: *improving the energy efficiency of the home*, so that it becomes more "fuel poverty proof", and the occupants are able to cope more reliably with fluctuations in income and fuel prices. UK data strongly support this analysis, showing how the fuel poor live in dwellings which have substantially lower efficiency ratings than the national average (Boardman, 2010).

"Energy efficiency improvements refer to a reduction in the energy used for a given service (heating, lighting, etc.) or level of activity. The reduction in the energy consumption is usually associated with technological changes, but not always since it can also result from better organization and management or improved economic conditions in the sector ("non-technical factors") (World Energy Council, 2013). Improving the energy efficiency of properties, and therefore reducing energy need among fuel poor households, is the best long-term and sustainable solution to eradicate fuel poverty and cold homes. Investments in energy efficiency can also deliver substantial environmental and economic benefits for communities (Boardman, 2010).

4.9 Energy Efficiency related policies

4.9.1 Warm Front (WF)

The Warm Front Program was installed in 2000 and has been referred to as the "governments flagship program" (Boardman, 2010) against fuel poverty in England. From 2000 to its temporary closure in 2011, 2.3 Million households received funds, which is about 11% of English homes, for a total of about 2.85bn £ (Parliament, 2011). This means that in 10 years WF has received roughly the same amount of funds as the Winter Fuel Payment did just for 2009.

Despite providing insulation for many households the WF program has been criticized because of its weak targeting. According to Boardman (2010) only 25% of the warm front expenditures actually went the homes of fuel poor. Reasons for this were a cap on receivable funds which is too low to help households in severe fuel poverty as well as the "first-come-first-serve" application procedure.

Warm Front usually only can provide limited measures, as there is a spending cap per households. This means that energy inefficient houses may for example only get either loft insulation or cavity insulation or floor insulation, but not all at the same time. This means that fuel poor households might actually still be in fuel poverty after being "treated" (Boardman, 2010).

The combination of a greatly reduced Warm Front budget and the need to better target this limited funding on fuel-poor households led to the introduction of new eligibility criteria from 2011. The revised criteria combined financial disadvantage, vulnerability and poor to modest energy efficiency standards. However the new, more rigorous eligibility criteria and the lack of any promotion for the scheme meant that Warm Front had a major underspend in 2011-2012.

4.9.2 Warm Zones

The Warm Zones program was initiated in 2000, it is administered by the National Energy Action with funding support from local, national government as well as EU funding. (Warm Zones, 2005). Unlike Warm Front, it does not accept applications by self identified fuel poor, but proactively targets deprived areas, approaches households and offers consultations on benefits, energy use as well as providing energy efficiency measures (Boardman, 2010). This happens in cooperation with local authorities, in order to most effectively target deprived areas. Unlike Warm Front, Warm Zones tries to offer holistic solutions for whole areas rather than targeting individual households. Ron Campbell from NEA states Warm Zones has met with "virtually universal approval" and may be one of the best ways to fight fuel poverty. *"The reason why Warm Front is so effective is because it allows for economies of scale as whole areas are targeted, rather than individual households. This way we can also avoid stigmatizing individual households."*

While several third-party evidence for the success of Warm Front (Boardman 2010**)** the programs' limited scale holds it back. WF programs have been initiated in several UK cities, but the program is far from covering the whole country, as funds are very limited.

4.9.3 Carbon Emission Reduction Target (CERT) and Community Energy Savings Program (CESP)

The Carbon Emission Reduction Target and the Community Energy Savings Program, was introduced in 2008 to replace the Energy Efficiency Commitment, an energy company which funded home insulation scheme. The primary policy goal is to reduce carbon emissions, however the government claims it will also benefit the fuel poor. During its duration the program 2008-2012 amounted to about 1bn. £ spent on insulation measures around the UK. Inspired by the success of Warm Zones, CESP more specifically targets deprived areas, its funding amounted to 0.35bn £.

Policies that use energy company funds are likely to cause higher fuel bills for costumers, burdening fuel poor with disproportional energy bills. This seems to be the case with CERT: While all costumers carry the costs of energy efficiency measures, only 15% of the funds will benefit the fuel poor who already have disproportionally high energy costs. It seems doubtful such a policy is beneficial for them, CESP may be better, as it specifically targets deprived areas. But as with CERT, all energy consumers will pay for measures, including fuel poor not being targeted by the program (Watson and Bolton, 2013; DECC, 2011b).

4.9.4 The Green Deal

The Green Deal was developed in response to the legally binding carbon reduction targets set out in the Climate Change Act 2008 (Great Britain, 2008). The scheme is designed to enable and to push households to improve the energy efficiency of their homes at zero upfront cost. As long as proposed improvements meet the "Golden Rule", (i.e. the expected financial savings must be equal to or greater than the costs attached to the energy bill), then the household will be able to install the intervention at no upfront cost to themselves, instead paying back the loan to the Green Deal supplier through an additional payment added on to the house's electricity bill.

While the focus of the policy is on carbon reduction, the Green Deal also offers an opportunity to tackle fuel poverty. The new Energy Company Obligation (ECO) will integrate with the Green Deal to enable low income households (often most at risk of fuel poverty) to access supported funding reducing the projected financial addition to the household energy bill. This will enable more expensive interventions, such as solid wall insulation to be undertaken on needy households where the Golden Rule would have otherwise not have been met.

4.9.5 ECO (Energy Company Obligation)

The Energy Companies Obligation (ECO) is an energy efficiency program that was introduced in UK at the beginning of 2013. It replaces two previous schemes, the CERT and the CESP. ECO places legal obligations on the larger energy suppliers to deliver energy efficiency measures to domestic energy users. It operates alongside the Green Deal and is intended to provide additional support in the domestic sector, with a particular focus on vulnerable consumer groups and hard-to-treat homes. Though this research focused on assessments undertaken for the purposes of the Green Deal, it is important to note that using a Green Deal assessment is one of the routes that energy companies can use to deliver ECO.

A large amount of early market activity has been driven by the ECO. Energy companies are using the Green Deal assessment route to deliver ECO. This means they are carrying out Green Deal assessments, installing energy saving measures and putting the benefits delivered by those measures towards their carbon targets. The Green Deal and ECO were designed to work together and there is significant overlap between them (DECC, 2014).

The ECO is the only energy efficiency program targeted at the fuel poor. It has three elements (DECC, 2014):

Affordable Warmth Obligation, which is focused on reducing heating costs. It provides energy efficiency measures to eligible owner occupiers and private tenants who receive certain means-tested benefits/ tax credits. The supplier offers that are on the market at present are largely focused on gas boiler repairs and replacements, and loft and cavity wall insulation. These measures are generally free but if a customer contribution is required the customer should be clearly informed and then decide whether they want to proceed.

Carbon Emissions Reduction Obligation, designed to lower fuel bills and reduce carbon emissions. The current scheme, available to households in all tenures, is designed to work alongside Green Deal, or other sources of finance, to provide energy efficiency measures for 'harder to treat' measures such as solid wall insulation. In December 2013, government announced proposals to allow standard cavity wall insulation, loft insulation and district heating to be installed under the Carbon Emissions Reduction Obligation, and the government is currently consulting on these changes.

Carbon Saving Communities Obligation, for reducing carbon emissions. It provides energy efficiency measures to households living in low income areas (defined by the Indices of Multiple Deprivation). 15% of Carbon Saving Communities Obligation must be delivered in rural areas.

4.9.5.1 Green Deal and ECO

In order to tackle fuel poverty, Green Deal and ECO provision will need to be focused on the most vulnerable and hardest to treat homes. These homes are often characterized by under-heating and associated health problems. The installation of an energy efficiency intervention may not result in a reduction in energy consumption in the household, but instead an increase in the thermal temperature of the house which will not be captured in reductions in UK fuel poverty statistics.

For fuel poverty to be reduced, the current and proposed methods of measuring fuel poverty for the targeting of policy must be revisited. The current measure is based upon a highly economic and technological indicator and current Green Deal and ECO interventions will have only limited impact predominantly on marginal fuel poor households. Hills' proposed measure of extent and depth will enable more accurate targeting of policy, focusing on low income, high cost households. In this case it is likely that a reduction in the depth of fuel poverty will be realized (i.e. there will be a reduction in the fuel poverty gap), however given that previously the house was under-heated, the opportunity to remove the house from fuel poverty remains remote. The additional charge associated with the Green Deal element of the intervention is likely to push the most vulnerable households beyond the median required energy costs mark, so while thermal comfort will be improved they will still be suffering from fuel poverty under the Hills measure.

In order to tackle fuel poverty it therefore seems vital that a more accurate picture of internal household temperatures is captured, along with a combination of other objective and subjective measures for the creation of a more complex measure of fuel poverty. Whilst Hills rejects the use of subjective measures of fuel poverty Fahmy et al. (2011), note the lack of overlap between those objectively defined as fuel poor and those who subjectively report as experiencing fuel poverty. This suggests that, in order to target Green Deal and ECO measures precisely and ultimately improve cold home related health and reduce the numbers in fuel poverty a more complex and accurate measure of fuel poverty, combining both objective measures and subjective reporting of fuel poverty experiences is required (Koh et al., 2012a).

4.10 The benefits of energy efficiency

4.10.1 Economic growth

Installing energy efficiency measures often requires local labour, and the investment has the potential to boost employment and economic growth.The business community considers this as important in the current global economic climate .There are also long-term growth benefits. For example, lower domestic energy bills can lead to higher disposable incomes that can be spent elsewhere in the economy, while businesses can see a reduction in running costs and so an increase in productivity. Simple changes in energy use behavior can deliver some of these benefits with little up-front cost (Economist Intelligence Unit, 2012).

4.10.2 Savings for domestic and business consumers

UK households are already benefitting from improvements in energy efficiency such as heating efficiency and insulation. Building Research Establishment modeling suggests that, if no energy efficiency gains had been made since 1970, current energy use would almost double their current levels, adding about £1000 to the average annual energy bill. Energy efficiency will continue to have a role in driving long term reductions in household energy bills (DECC, 2012b).

4.10.3 Emission reductions

To deliver against greenhouse gas emission targets over the coming decades in the most cost effective way, energy efficiency is needed in order to improve significantly across all sectors.The 2011 Carbon Plan sets out scenarios through which the UK could meet its legally binding target to reduce greenhouse gas emissions by 80% between 1990 and 2050.The Carbon Plan 2050 scenarios require energy efficiency to contribute a reduction in final energy consumption per capita between 2007 and 2050 of 31-54%. The current policy package is on track to be comfortably within this range through to 2020 but additional action is needed to maintain progress after 2020 and energy efficiency tends to be a cost-effective option (DECC, 2012b).

4.10.4 A sustainable and secure energy system

Through reducing energy consumption the UK's energy security is improved. A more energy efficient UK will have lower exposure to international energy market price rises and volatility.There can also be specific benefits to the energy system of decreasing demand as it reduces the long-term need for investment in additional infrastructure that would have otherwise been required.This has the potential to reduce the overall cost of the energy generation framework in the future (DECC, 2012b) gap. The Plan contained a range of proposals for action across all sectors of the economy to which the EU Energy Efficiency Directive is intended to give legislative effect. It will also replace and repeal two existing Directives: the Co-generation Directive (2004/8/EC) and the Energy End Use Efficiency and Energy Services Directive (2006/32/EC).

CHAPTER 5: Conclusions

5.1 Review

In this chapter the study's conclusions and recommendations are presented for further debate at European level on the issue of fuel poverty. The scope of this thesis was to depict the problem of fuel poverty through a literature survey on the extent of the problem, initially clarifying key terms used in world literature. Although the problem is visible and affects a very large percentage of the EU population, the term is not analyzed and not explained adequately, because of the lack of a definition at European level. This is demonstrated by the fact that efforts to measure poverty is identified in only six Member States with basic guide the UK.

5.2 Conclusions

More than twenty years have passed already since the publication of Boardman's first book on fuel poverty (Boardman, 1991); however, there is still a lack of studies investigating the matter from the perspective of the people concerned and their energy practices, conditions of action, and coping strategies (Boardman, 2010; Radcliffe, 2010). Studies including qualitative aspects have to date exclusively been conducted for selected groups of people on low incomes and/or in situations of fuel poverty (frequently elderly people), or have highlighted certain practices (often heating practices) or problems (e.g. health issues) related to energy consumption (Day and Hitchings, 2009; Gilbertson et al., 2006; Hernandez and Bird, 2010; O'Sullivan et al., 2011; Wright, 2004). What is still missing are investigations into the decisive factors of fuel poverty (financial conditions, status of housing and how energy costs are dealt with, amongst others). Therefore, a holistic approach to the daily energy practices of households on low incomes and/or suffering from fuel poverty is necessary (Brunner et al., 2011).

Whether a household is in fuel poverty is determined by the interplay across three factors:

- the energy efficiency of the property
- energy costs
- household income.

It is also influenced by factors such as:

- heating-related health needs
- occupancy levels related to the size of property
- attitudes to heating-related expenditure
- cold-related behaviors in the home; for example, strategies to compensate for lack of warmth
- housing tenure

- access to mains gas
- the external environment

Up to a quarter of the EU population currently can not afford having a comfortable indoor environment. These people are living with the risk of health damages and social exclusion. Many member states of the EU recognize this social problem, even though there is no single definition of fuel poverty. Different terms are used to describe people affected: fuel poor, energy poor, vulnerable energy consumers or, to a larger spectrum, at–risk-of-poverty or low-income people.

Those most vulnerable to fuel poverty and the impacts of cold, damp homes are:

- older people – particularly those living on their own and/or in larger family homes
- lone parents with dependent children
- families who are unemployed or on low incomes
- children and young people
- disabled people
- people with existing illnesses and long-term conditions (physical and mental)
- single unemployed people.

While there are links to wider poverty issues that have an impact on broader health and wellbeing, fuel poverty requires a special focus because:

- not everyone on a low income is fuel poor – for example, low income households living in energy efficient properties that are easier and therefore cheaper to heat
- approaches to address fuel poverty are not just income-related – home energy efficiency improvements are a mainstay of affordable warmth strategies
- it is associated with specific illnesses and health conditions that have a more immediate impact on health outcomes than outcomes associated with poverty more generally
- it is possible to effect change on fuel poverty more quickly than with approaches to tackle income poverty
- capital expenditure, such as that needed to improve homes, can have a major impact on reducing fuel poverty; general poverty, on the other hand, mainly requires revenue expenditure.

At the European level, there is no dedicated survey of fuel poverty, and no standardized household micro-data on energy expenditure. At the national level, attempts to measure fuel poverty have been made in just six of the twenty-eight member states (Austria, Belgium, France, Hungary, Ireland and the UK), and with the exception of the UK, studies in the remaining countries have nearly always incorrectly applied the UK's 10% definition, with authors using a 10% (actual) fuel expenditure threshold, without transferring the underlying methodology.

Moreover, five pan-European analyses of fuel poverty have been conducted, however, they have all used data from before 2008, predating the worst increases in gas and electricity prices, as well as decreasing incomes overall due to the global financial recession. While the use of modeled required energy expenditure is desirable, it is not at the present effective as most countries do not collect sufficiently detailed housing and energy efficiency data. Hence, there is a need for good quality standardized statistical data concerning housing stocks, energy efficiency, energy consumption, individual energy needs and health effects.

5.3 Recommendations for reducing energy poverty in the EU

The studies which are included in the previous chapters have provided a partially comprehensive level of detail about vulnerable households in Europe. As a result, they prevent the efforts to produce robust frameworks across European member states. This study leads to the following recommendations:

- **There is a need to improve the measurement of European fuel poverty.** There is no thorough survey of fuel poverty and no standardized household micro-data on energy expenditure, energy consumption or energy efficiency. As a consequence, researchers are reliant on subjective data concerning the consequences of fuel poverty, such as arrears on utility bills and the presence of damp in the home, rather than data on the causes of fuel poverty, such as high energy costs and specific energy demands. This can be done by amending and harmonizing the existing surveys in EU, which are EU SILC and HBS (see chapter 3). EU SILC is the most widely used survey for quantifying aspects of European fuel poverty, but was not designed to measure fuel poverty from the beginning and as such provides imperfect estimates of the problem. Another option is to harmonize HBS surveys and create a pan-European dataset of actual fuel expenditure across Europe. These surveys should be conducted in all EU member states and contain data on household expenditure on goods and services, including household energy. It is evident from the literature review that actual fuel expenditure is a poor indication of fuel poverty, as low income households often spend significantly less on fuel than would be required to maintain a warm home (Moore, 2012). It can be useful to harmonize HBS data on fuel expenditure for exploring seasonal and annual variations in energy expenditure and for investigating differences in expenditure between different types of households.

- **Creation of a pan-European household survey of fuel poverty.** By creating a new dedicated pan-European household survey of fuel poverty, the limitations of existing data and the difficulties associated will be overtaken with amending current surveys. This would progress efforts to address fuel poverty, which has been identified as a key priority by numerous EU institutions, such as Directives 2009/72/EC and 2009/73/EC. Likewise, fuel poverty would be recognized as a policy problem, not only social and will lead to better policy frameworks across Europe.

- **Improvement of statistical data collection by providing more evidence on the scale and impact of fuel poverty in the EU.** While Eurostat and National Statistics Institutes provide good evidence of people at-risk-of-poverty and some indicators related to housing conditions and energy bills arrears, there is a need to have more linkage between these data in order to better identify the relationship between housing conditions, fuel poverty and other drivers of people's vulnerability on energy issues.

- **There is a need to create a pan-European definition of fuel poverty.** The EU must set out a clear definition of fuel poverty. This may be quite general but should recognize the key issue of inability to achieve adequate warmth at an affordable cost. Member states should recognize energy poverty and refine the common definition according to their own national circumstances. For example, in the UK a household is deemed to be fuel poor if it requires to spend 10% or more of income on essential energy services. Likewise, the definition of a proper standard of heating depends on country and climate. Moreover, it would be valuable if the EU were to reach a common position on what constitutes "vulnerability".

- **Emendation of the existing regulations.** Existing EU legal documents that directly or indirectly tackle fuel poverty constitute a starting to reduce fuel poverty. The already existing regulations can be amended. For example, Directives adopted in 2009 relating to the internal gas and electricity markets may detail the role of member states, in addition to protection of vulnerable customers, in aids for improvements of the energy efficiency of housing stock in the context of energy poverty policies. Moreover, an amendment to Directive 2002/91/EC on the energy efficiency of buildings might set higher standards, particularly in publicly or privately owned local authority housing, in which energy efficiency criteria ought to be more stringent. Finally, objectives linked to energy poverty should be incorporated in the various tools set up by states in the context of the European energy policy program (EPEE, 2009).

- **Need for a long-term strategy for fuel poverty alleviation in the EU.** Fuel poverty is a social priority and needs support at all levels. The EU is an effective institution in a number of areas, but as the situation deteriorates the EU (as far as the economic recession is concerned) should have greater involvement and establish common guidelines and references for all member states. Although EU legal documents are good in principle, the reaction of member states has been inadequate to date and, as an example, only six of the European member states have introduced social tariffs for economically disadvantaged users. In the absence of effective national legislation to protect vulnerable consumers, it would seem rational and equitable that the EU should take a much more active role in safeguarding the interests of these consumers.

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Financial crisis and energy consumption: A household survey in Greece

Mathew Santamouris [a], John A. Paravantis [b,*], Dimitra Founda [c], Dionysia Kolokotsa [d], Panagiota Michalakakou [e], Agis M. Papadopoulos [f], Nikoletta Kontoulis [b], Anna Tzavali [e], Eleni K. Stigka [e], Zisis Ioannidis [a], Amantin Mehilli [a], Alexander Matthiessen [a], Eirini Servou [b]

[a] University of Athens, Greece
[b] University of Piraeus, Greece
[c] National Observatory of Athens, Greece
[d] Technical University of Crete, Greece
[e] University of Patras, Greece
[f] Aristotle University of Thessaloniki, Greece

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ABSTRACT

This research aims to investigate, analyze and characterize the relation between the economic crisis and energy consumption in Greece. A survey held in the spring and summer of 2012 collected data of the heating energy consumption for 2010–2011 and 2011–2012, from 598 households via a questionnaire. Comparing the 2010–11 winter to the harsher winter of 2011–12 showed that inhabitants consumed less energy during the winter of 2011–12 because of the rapid economic degradation. Important conclusions were drawn regarding the energy consumption of the households which during the harsh winter 2011–12 was 37% less than expected. Cluster analysis rendered two distinct clusters: three fourths of the households belonged to the lower income group that lived in a smaller space, had half the income and consumed more specific energy compared to the high income group, although much less than expected based on the degree hours of the second winter. One out of three higher-income and one out of four lower-income households adopted some conservation measures after the first winter while 2% of the higher income households and 14% of the lower-income households were below the fuel poverty threshold. Directions for further research include monitoring of low income households with sensors.

1. Introduction

It has been asserted that one of the most eminent social problems of the 21st century is fuel poverty, which has been recognized as a distinct form of inequality and an unacceptable feature of the present time [1,2]. It affects the poor and its roots are detected in the quality of the housing stock and the cost of fuel, particularly high in these times of global financial crisis and peak oil. A sufficient standard of warmth is usually identified as 21 °C for the main living area, and 18 °C for other occupied rooms [3]. The fuel poverty ratio (FPR) is identified as

$$\text{Fuel poverty ratio} = \frac{\text{energy consumption} \times \text{price}}{\text{income}}$$

and if it is greater than 0.1, the household is considered to be fuel poor [4]. FPR compares the cost of energy consumption to the income of a household [5] and is an interaction of three factors: the energy efficiency of the household, the cost of energy and the household income [6]. Although FPR does not reflect underlying problems and causes, it is the only indicator that shows both the extent and the depth of fuel poverty.

The term fuel poverty has been used since the early 1980s [7] and was defined by in 1991 as the difficulty or even inability of a family to afford the funds for proper heating at home [2]. Fuel poverty was officially recognized as a problem when the United Kingdom (UK) Minister at the Department of the Environment, Transport and the Regions (DETR) stated that an integrated approach across government to tackle fuel poverty and energy efficiency would be taken and that coherent policies should be produced aiming to go to the heart of the problem [2]. When the Third Energy Package led to the integration of energy poverty, within Directives 2009/72/EC and 2009/73/EC of the European Parliament and of the Council, it was

* Corresponding author at: Department of International and European Studies, University of Piraeus, 18534, Greece. Tel.: +30 210 4142771; fax: +30 210 4142779.
E-mail addresses: jparav@unipi.gr, parava@otenet.gr (J.A. Paravantis).

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the first time energy poverty entered the vocabulary of European Union (EU) institutions [8].

Poverty and fuel poverty are linked, but not synonymous concepts [2]. A vulnerable household is defined as one that contains children, elderly people and persons that are disabled or have a long term illness [2,5]. In the UK, the fuel poor have been categorized into poor households, vulnerable households and households with high energy bills with payment difficulties. Unfortunately, it is difficult to identify fuel poor households because the information needed is never held by one single entity and often cannot be communicated for reasons of privacy [9]. The calculation of fuel poverty is based on annual fuel costs set against annual income. Fuel costs in winter are likely to be more difficult to be paid by poorer households that pay for their gas and electricity using pre-payment meters and quarterly standard credits (compared to those that pay a set monthly amount by direct utility bill). A recent EC Working Paper suggests that those in fuel poverty could be defined as "*households that spend more than a pre-defined threshold share of their overall consumption expenses on energy products*" with the threshold set at "*double of the national average ratio number*" [10,11].

In addition to space heating, fuel-related costs may include spending on energy for water heating, lights, appliances and cooking. Fuel poverty is therefore not based on what a household actually spends on energy. As fuel poverty is a measure of what a household needs to spend on energy rather than what it actually spends, total energy needs are modeled by various factors, including the size and energy efficiency of the property, household size and type and the type of heating [12]. Energy efficiency is very important as it affects the fuel requirement of a household and it is affected by energy efficiency measures [6].

Fuel poverty is primarily a determinant of three household factors: income, energy prices and energy efficiency of dwellings. In most cases the profile of fuel poor people are those who receive social security payments, work part time or are in debt. Unemployment rates, growing job insecurity (part time employment, short-term jobs) lead a lot of people to live below the poverty threshold [4]. Beyond building degradation, fuel poverty translates into physical and mental health issues, e.g. cold temperatures can affect the immune and the cardiovascular system while damp cold houses influence negatively people who suffer from respiratory problems and allergies. A survey conducted among five countries (Belgium, France, Italy, Spain and United Kingdom) analyzed causes and consequences of fuel poverty, helped realize the difficulties faced by the people living in such a situation, and gave the opportunity for reflection on an appropriate strategy to wipe out this phenomenon [13]. At the same time, this study revealed the lack of data and of relevant studies beyond the UK.

Only three out of the 27 EU member states have officially defined fuel poverty. All existing definitions stress the relationship between low income and energy efficiency [14]. According to its most widely accepted definition (UK), a fuel poor household is one that needs to spend more than 10% of its income to achieve adequate energy services in the home [15]. This threshold figure was adopted in an investigation of the problem of affordable warmth by the Energy Report of the 1991 English House Condition Survey (EHCS) [16], an annual survey, commissioned by the Department of Communities and Local Government (CLG), which involves physical inspection of properties by professional surveyors. In April 2008, EHCS merged with the Survey of English Housing (SHE) to create the English Housing Survey [6]. In the UK in particular, because of the prepayment systems, the problem of debt is not as great as in other countries although it is still estimated that around one billion British pounds of debt is owed to energy suppliers by consumers. Unfortunately, the recent rise of energy prices (and further rise expected) will make it more and more difficult for this category of people to pay energy bills [13]. In the UK, fuel poverty is seen as a rights-to-warmth issue and it has become a matter of justice and entitlement to healthy living [17]. In fact, the UK appears to be the only country that has presented policies and scientific programs on fuel poverty, supporting vulnerable households that face inadequate heated homes and health problems [2].

Turning to European countries, the UK is a pioneer on fuel poverty surveys. Fuel poverty in England is researched with the English Housing Survey (EHS); in Scotland, by the Scottish House Condition Survey (SHCS); the Living-in-Wales Survey is used to estimate fuel poverty in Wales; finally, the Northern Ireland House Condition Survey is used to calculate the Northern Ireland fuel poverty levels [6]. There is also the National Ecosystem Assessment (NEA), which is the UK's leading fuel poverty charity campaigning for affordable warmth. Finally, a European project called European Fuel Poverty and Energy Efficiency (EPEE) aims to improve the knowledge of fuel poverty and identify operational mechanisms to fight against this phenomenon [6].

In a survey of energy efficient British households, it was shown that fuel poverty is a complex socio-technical problem that may be explained using a combination of physical, demographic and behavioral characteristics of a residence and its occupants [18]. A Structural Equation Model (SEM) was introduced to calculate the magnitude and significance of explanatory variables on dwelling energy consumption. Using the English House Condition Survey (EHCS) consisting of 2531 unique cases, the main drivers behind residential energy consumption were found to be: number of household occupants, floor area, household income, dwelling efficiency (determined by the Standard Assessment Procedure or SAP), household heating patterns and living room temperature. The number of occupants living in a dwelling was shown to have the largest magnitude of effect, floor area and household income while there is strong mediation between causal variables. Statistical analysis implied that homes with a propensity to consume more energy will be more expensive to decarbonize due to the law of diminishing returns, a finding of concern in the context of global climate change.

In another UK study, strategies of low-income households for coping with limited financial resources and cold homes in the winter months were investigated [19]. The sample of 699 households with an income below 60% of the national median income included in-depth interviews of a subsample of 50 households. Findings showed that the primary strategy adopted by low-income households to cope with financial pressure was to reduce spending, including spending on essentials such as food and fuel. Just below two out of every three (63%) of low-income households had cut their energy consumption in the previous winter and almost half (47%) had experienced cold homes. Very low income households could not afford any heating. For households surviving on very small domestic budgets, it is a sad truth that the extra cash-in-hand could be more attractive than a warmer home.

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". A survey conducted in Ireland noted that existing households needed more fuel than others either because their circumstances imposed that they be heated for longer periods of time or because they were occupied by the elderly or those with very young children so they demanded higher temperatures [20]. Households were investigated based on demographic, educational and socioeconomic variables. A very strong relationship was found between the incidence of fuel poverty and social class. As expected, there was a very strong correlation between fuel poverty and income. Results regarding the severity of fuel poverty by income level were mixed, as they revealed both high- and low-income households suffering from high levels of chronic fuel poverty [21]. Many large families find it difficult to heat their home adequately over time, a troublesome result as health effects of cold and damp exposure are particularly intense among children. It was also found that housing tenure gave households varying levels of control over their home, heating systems and their energy consumption and was identified as an important dynamic of fuel poverty.

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" [14]. The first measures targeting low-income fuel-poor households in France, were developed in the middle of 1980s [9]. However, it was only in 2010 that the current fuel poverty policy was instituted. Its basis is a program called *habiter mieux*, which supports the thermal renovation of low income households, which are located in rural areas. The aim was for 300 thousand households to be thermally renovated with financial support from a budget of 750 million euros managed by the National Agency for Habitat Improvement (ANAH). It is noted that a household may benefit from the program *habiter mieux*, if it has a project of thermal renovation that would result in an improvement of at least 25% of its energy efficiency.

A survey of 964 houses in Belgium compared insulated to non-insulated homes [22]. Calculation tools were found to predict heating energy consumption assuming typical dwelling use although this was subjected to physical restrictions and the average temperature in partially heated homes increased with higher insulation quality as expected. An average indoor temperature of 18 °C was considered usual.

In a German survey, Michelsen and Madlener [23] investigated the preferences of home owners for applying improved Residential Heating Systems (RHS) and found incentives for adopting RHS to vary among families. Homes that use gas and oil for heating were found to prefer energy savings whereas the ones using heat pumps or wood pellet fired boilers prefer to be independent of fossil fuels. Analysis of the data also showed that the grant from the Federal Office of Economics and Export Control (*Bundesamt für Wirtschaft und Ausfuhrkontrolle*, BAFA), which would be important for the adoption of RHS, does not play a role in the decision-making process. It was suggested that RHS manufacturers in Germany improve their marketing strategies in order for home owners to take the adoption decision, having in mind not only their behavior but also age, size etc. of their homes. In another German study, Schuler et al. [24] found both technical characteristics of buildings and utilization patterns of households to be essential factors of the demand of space heating of private West-German households. The paper considered that the energy consumption for space heating may vary broadly and depends not only on socio-economic developments but on political actions as well. Such considerations may motivate governments lower the barrier for energy investments and apply policies that provide incentives for insulation of dwellings. Energy consumption related behavior was also targeted by Braun [25] who investigated both East and West German households. Braun asserted that socio-economic characteristics together with building type and region are important determinants of the space heating technology applied. The paper focused on building features such as construction age that was found to play a more important role than home ownership.

In nearby Austria, the NELA project (German acronym for "Sustainable Energy Consumption and Lifestyles in Poor and at-Risk-of-Poverty Households") investigated energy consumption in households in Vienna, Austria [26]. NELA surveyed 50 Viennese households afflicted by poverty and compared them to ten better-off households. The interviews were conducted during the summer of 2009 and the spring of 2010.The results identified four distinct types of households: "the overcharged", "the modest fuel poor" (fuel poor), "the modest non-fuel poor", and the ones "on a low income" (non-fuel poor). Similar classifications were found by a survey conducted in France by Devaliere [27] as quoted by Brunner et al. [26]. It was confirmed that low income households try to cope by adopting various energy conservation measures.

Buzar [28] claims that fuel poverty is apparent in post socialist countries of Eastern and Central Europe and the Former Soviet Union. The author mentions to the "*hidden*" geography of poverty, referring to the lack of heating in the households of these countries. A survey held in FYROM and the Czech Republic showed that low income households are energy poor and areas of energy poverty (called "hidden") appear dull and messy due to specific circumstances of the post-socialist frame of these regions.

Turning to Southern Europe, in Italy, the E-SDOB (Statistical Distribution of Buildings) tried to address heating energy issues by defining the performance scale for energy certification of buildings, and evaluating the building volume falling in different classes [29]. E-SDOB has also been used to evaluate the energy saving potential of large scale retrofit actions on the building envelope. E-SDOB seems to be a useful tool for a better knowledge of the regional building stock as well as the adoption of coherent energy regulations. As the authors point out though, the global overview of the building stock energy performance provided by E-SDOB may provide further insight but it cannot replace specific analyses at a building level when retrofit actions have to be implemented.

In Spain, the Environmental Science Association (*Asociación de Ciencias Ambientales*, ACA) started a project named REPEX aiming to research the relationship between fuel poverty and unemployment. This project claims that fuel poverty in Spain is caused by unemployment and that the renovation of houses, in order to be efficiently heated, could offer employment to workers that lost their jobs because of the financial crisis. However, fuel poverty in Spain is not a first priority issue either to the Spanish Political Parties or to the media [30].

All in all, since fuel poverty lacks an official Europe-wide definition, comparing fuel poverty among European countries is not trivial [5].

A United States (US) survey conducted among families of equal economic status over a 15-year period (1987–2002) during the winter heating season in Seattle, Washington, USA (which has a climate similar to that of the eastern Mediterranean) showed that, regardless of life style, the space heating energy behavior of the tenants remained constant [31]. The results of the survey suggested that estimates of energy savings could be based upon envelope thermal resistance for moderate occupant behavior. For such behavior, space heating was well characterized by the difference between house temperature and outside air temperature. It is encouraging to note that over 15 years in which houses sustained considerable wear and tear as expected of rental properties, the space heating behavior did not change, i.e. the envelope tightness did not seem to degrade and the sensitivities remained constant.

A survey carried out in New Zealand, with houses poorly insulated and rental properties not required to have insulation or heating, showed the inability of many households to afford adequate heating [32]. Three of the main factors included: the poor quality of housing in terms of thermal efficiency; relatively high levels of income inequality compared to other Organization of Economic Cooperation and Development (OECD) countries [33]; and an increase in the real price of residential electricity, which occurred mainly after the deregulation of the industry in 1996 and 1998. Vulnerable population groups particularly those on low income, the old and the young (who are more likely to suffer health consequences) pressured the New Zealand governments to translate research into policy. The problem's antecedents were targeted, including inadequate standards for existing houses, rising income inequality and the need to protect low-income households from the rising price of heating fuels. A suggested policy to face fuel poverty in New

Zealand was prepayment metering as a method to pay for electricity, helping households that faced disconnection and wished to lower their expenditure [34]. As in many areas of Southeaster Europe and Greece, economic difficulties faced by the lower income clusters in New Zealand mean that as both unemployment and fuel poverty will intensify.

An energy conservation survey of 10 Japanese residential buildings, showed that energy-saving consciousness was raised and energy consumption reduced by energy saving activities of the household members [35]. An improved online tool for the registration of energy consumption information revealed that the power consumption of many appliances and the total energy consumption of the household were reduced by 18% and the total city-gas consumption decreased by 9%. Also, savings of 20% in space heating were achieved by residents that switched to more energy saving sources or reduced the duration of space heating.

During the winter of 2003–04, a questionnaire survey was undertaken of more than 200 residential households in the rural fringe of Xian City in China [36]. Fuel consumption, including the use of biomass for cooking and space heating, was investigated; stove types, stove use and characteristics of residents as well as residential houses were also reported and analyzed. The survey aimed to quantify energy consumption, emissions of greenhouse gases and air pollutants in rural areas of China. The survey showed that energy consumption in rural areas in China includes biomass fuel, in particular a mixture of agricultural waste and twigs commonly used for *kang* (a traditional cooking stove), coal and liquefied petroleum gas (LPG). It was proposed that there is a relationship between income level and priority of LPG use and that the energy consumption level of rural households in China remains a subject for further work.

In wrapping up this section, it is added that surveys on fuel poverty during the last decade in Europe have not come up with dramatic changes from year to year [37].

Nowadays, with the global financial crisis, it is suspected that fuel poverty is a substantial problem especially in areas of lower income such as southeastern Europe. Given the dearth of published research on fuel poverty in these areas, this research measures fuel poverty in Greece and investigates the impact of the global financial crisis on the energy consumption of households via a number of questions that look into how various socioeconomic, environmental and consumption variables relate to fuel poverty.

Literature review will be completed with a look into empirical research in Greece, carried out in the next section.

2. Energy consumption and economic situation in Greece: existing research

Turning to investigations in Greece about the specific energy consumption of households and its relation to the economic situation, a 2004 survey held in Athens, collected social, financial, energy and technical data from about 1110 households [38]. These households were divided into seven income groups and a detailed analysis showed that there was an almost direct relationship between income and household area. It was also found that higher income was associated with newer buildings and that almost 64% of the families in the lower income group lived in apartments (the corresponding number for the more affluent group was 48%). Low income families lived mostly in the lower part of multistory buildings while high income households live mainly in the higher part of the buildings. Only 28% of people in the poorest group dwelled in insulated buildings, with the corresponding figure for the richest group being close to 70%. High income families paid almost 160% higher annual costs than the low income ones. Low income households paid nearly 67% higher electricity cost per person and square meter than high income households. Furthermore 1.63% of the households suffered from fuel poverty and 0.35% from severe fuel poverty (2004 values). Fuel poverty in low income groups, was in the region of 16%. Severe fuel poverty, in the low income group, was calculated close to 4%. Concerning energy poverty, the average percentage of the households spending more than 10% of their income for energy was close to 11.3%, while 2% spent more than 20%. Almost 40% of the low income group, called the energy poor, spent more than 10% of their income for energy while almost one fifth of the poor households, called the severely energy poor, spent more than 20% of their income for energy. Fuel and energy poverty reached quite high levels in the low income groups, with a dramatic increase attributed to the fuel prices. It was concluded that energy policies addressed to the dwelling sector should set as a priority the improvement of the envelope quality of residents where low income people are living.

In another study referring mainly to the summer conditions, [39], it was found that low income population in Athens, lives in areas where the heat island is well developed. Recent studies have shown that temperature increase in high density areas suffering from heat island may reach 5–7 K, depending on the local climatic conditions, [40,41]. Higher urban temperatures increase considerably the necessary energy consumption for cooling purposes [42,43], affect thermal comfort conditions, [44] and increase pollution levels [45]. Monitoring of a high number of low income households in Athens during the heat waves of 2007 [46], shown that indoor temperatures as high as 40 °C occurred while the average indoor minimum temperature was always above 28 °C.

A study of a typical multi-family Greek building in 2007 compared commonly used heating sources (including oil), natural gas and autonomous systems [47]. The cost distribution of central heating was determined to favor penthouses over apartments in intermediate floors, possibly failing to motivate some occupants to promote energy conservation while at the same time not providing motivation for superior insulation of the roof of a building. The authors asserted that the use of electrically driven heat pumps can be a very good solution for heating Greek buildings, since (at the time of writing) they were in some cases equally expensive to other fuels. It was also suggested that the increased potential of renewable energy sources in electricity generation (mainly wind power) might also be improved. The authors expected the rationalization of electricity tariffs to enable the installation and use of heat pumps as central heating systems, increasing in turn their market infiltration.

Sardianou [48] highlighted the use of statistical models in determining domestic consumption of Greek households. The results of the survey held in 2003 in Greece, unveiled that various characteristics such as the number of persons in a household, the type of the building and the ownership status, influence the domestic demand for heating. Findings confirmed that there is a relationship between household annual income and annual fuel consumption while there were already (back then) households that had decreased their heating consumption in view of increasing oil prices.

Finally, according to the most recent opinion survey of fuel poverty in Greece [49], the median specific energy consumption of buildings in Athens was found to equal 29 kWh per cubic meter, greater (the author asserted) than that of other countries with more adverse weather conditions such as Denmark, Germany and the Netherlands. Fuel poverty was calculated with three different methods based on (a) the proportion of energy expenditures of a household, (b) the opinion of residents on their energy coverage and (c) the condition and conveniences of the household. From 1988 to 1997 Greece was found to have a seasonal rate of mortality of 18%, which ranked it at a position higher than that of other countries with heavier winters. Panas refers to the relation between the inadequate heating of households and the increased mortality rate during the winter season. However, through a recent questionnaire survey in northern Greece conducted in November of 2012, 814 people were asked whether they paid more than 10% of their annual income for heating (it is noted that this is a subjective method of documenting fuel poverty). According to the survey, respondents declared their inability to pay the heating bills and their fear for consequences of the current economic crisis in the future, supporting the notion that Greek households are not presently energy efficient.

Important research has been carried out to develop and propose proper mitigation and adaptation techniques to improve the environmental performance of low income households [50,51]. Applications in real scale projects showed that it is possible to improve considerably the environmental quality of buildings and open spaces, decrease the energy consumption and improve the quality of life of low income citizens [52].

3. Methodology

3.1. Research questions

A number of key research questions are gleaned from the literature and are listed below:

1. How do building characteristics and socioeconomic data relate to fuel poverty?
2. In particular, how does family income impact fuel poverty?
3. How do different heating sources relate to fuel poverty? Fuel poor cannot afford relatively expensive high fuel such as electricity, natural gas and liquid petroleum.
4. How are heating hours and other measures of energy use related to fuel poverty? Fuel poor households try to curb energy consumption by reducing their heating hours oftentimes irrespective of climatic conditions.
5. What conservation measures are usually taken by households in order to combat energy consumption and fuel poverty in a time of falling incomes? Such measures may depend on factors such as household size, heating sources and energy efficiency.
6. What are typical values of specific energy consumption measured in kWh per m^2? It is noted that electricity prices for household consumers should not exceed 0.10 euros per kWh in order to be considered affordable [53].
7. Are households typically clustered into groups that indicate social class? How big a role is played by annual family income and the type of family, i.e. number of children, senior citizens, members or with disabilities? What percentage of each cluster is fuel poor?
8. What policies and measures have been adopted especially in Southern East Europe and the Mediterranean? This question will be partially addressed as results are synthesized into conclusions.

To answer many of these questions, a survey was carried out in this work as explained below.

3.2. Survey

This survey focused on Greece, covering a wide variety of bioclimatic types. The survey was done in the spring and summer of 2012. A total of 598 households were polled with a questionnaire and data were gathered for the winter of 2010–11 (milder) and the winter of 2011–12 (harsher). The climatic conditions that prevailed over Greece during the two successive winters of 2010–2011 and 2001–2012 were remarkably different. Winter 2010–2011 ranks among the warmest winters on record in Greece according to the historical archives of the National Observatory of Athens, dating back to 19th century. In particular, winter 2010–2011 was the 3rd warmest on record with a maximum temperature averaging 16.6 °C from November to February, 2 °C above normal (with respect to the 1961–1990 period) for the 4-month period. It is notable that November 2010 was the second warmest recorded ever. On the contrary, winter 2011–2012 ranks among the 15% of coldest winters on record, with maximum and minimum temperatures averaging 13.5 °C and 6.6 °C respectively from November to February, approximately 3 °C lower than the corresponding temperatures of winter 2010–2011. It is also remarkable that November 2011 ranks among the 5 coldest on record.

The data were collected either by live interview of members of the household (adhering completely to the questionnaire) or by e-mailing the questionnaire. A follow-up by telephone of the households was carried out in order to confirm that collected data were correct; these households were selected from the sample systematically so as to cover both data collection modes and all personnel that collected data in the field.

Data were inspected for outliers; some rather large income values were located but none so large as to warrant exclusion from the data set. For buildings that were renovated, the renovation year was used to estimate the age of the buildings. As regards insulation, it is noted that buildings constructed: prior to 1980 lack insulation; from 1980 to 1990 have some ("flexible") insulation; and after 1990 are properly insulated.

A question relates to the energy consumption of apartments (as opposed to that of detached houses): does the reported energy consumption of households that live in apartments represent the energy consumption of the apartment or the entire apartment building? In many cases energy consumption was reported in monetary terms and, thus, represented correctly the energy consumption of the household.

4. Results

Variable names and selected descriptive statistics are shown in Table 1.

The sample comprised 598 households that were located in a wide variety of geographical regions and bioclimatic types of Greece, including: Attica, Crete, parts of Peloponnese and the Cyclades islands (intense thermo-Mediterranean); Mainland Greece (weak to intense Thermo-Mediterranean); Thessaly (weak to intense meso-Mediterranean); Macedonia (i.e. northern Greece, sub-Mediterranean); and other local bioclimatic types in Peloponnese (weak to intense meso-Mediterranean, intense thermo-Mediterranean).

Most households were located in Athens and Attica (78.4%) with a 10.2% in Crete and a 9.7% in Peloponnese. Greek Macedonia and the rest of Northern Greece were underrepresented, something that may be addressed in a future work.

4.1. Descriptive analysis

Of the 598 households that were surveyed, three-fourths (452, i.e. 75.6% if the total) lived in apartments with the rest one-fourth (146, i.e. 24.4% of the total) living in detached houses. Buildings were constructed (or renovated) from 1900 to 2010, i.e. building age varied from 2 to 112 years with an average value of 28.6 years; age distribution is shown in Fig. 1 and shows two peaks corresponding to periods of pronounced building activity fueled by economic growth (circa 1980 and 2000).

On the average, detached houses (31.3 years of age) were a little older than apartments (27.8 years). Surface area varied from 25 to 252 m^2 for apartments and from 50 to 400 for detached houses. The average surface area of apartments equaled 88.7 m^2; for detached

Table 1
Basic statistics for quantitative variables.

Variable name		Min	Max	Mean	Mode
DEGRDAYRATIO	Degree days ratio of area of household	1.26473	1.40310	1.35606	1.34897 (n = 469)
Q3MEMBERS	Number of persons in household	1	8	2.99497	4 (n = 180)
Q4M2	Household surface area (m^2)	25	400	96.4573	120 (n = 56)
Q5RENAGE	Building age since construction of last renovation (years)	2	112	28.6173	32 (n = 53)
Q7FLOOR	Household floor (if apartment)	−0.5	12	–	1 (n = 136)
Q9SALAR09	2009 income (euros)	0	200,000	26,221	30,000 (n = 38)
Q10SALAR10	2010 income (euros)	0	200,000	24,900.2	
Q11SALAR11	2011 income (euros)	0	200,000	22,497.8	10,000 (n = 34)
Q12OIL	Heating oil dummy variable	0 (n = 131)	1 (n = 465)		1
Q13GAS	Natural gas dummy variable	0 (n = 519)	1 (n = 63)		0
Q14AC	Air conditioning dummy variable	0 (n = 193)	1 (n = 405)		1
Q16BTU	Installed air conditioning (BTUs)	6000	84,000	25,390.1	9000.0 (n = 52)
Q18HOUR	Hours of operation of air conditioning	0.140	24	3.89724	2 (n = 61)
Q31CONSERV	Conservation measures dummy	0 (n = 386)	1 (n = 196)		0 (n = 386)
FUELPOVRAT1	Fuel poverty ratio (winter 2010–11)	0.0015	0.6	0.051171	0.05
FUELPOOR1	Fuel poor dummy (winter 2010–11)	0 (n = 415, 88.9%)	1 (n = 52, 11.1%)		0
FUELPOVRAT2	Fuel poverty ratio (winter 2011–12)	0.001	0.666667	0.0550866	0.0333333
FUELPOOR2	Fuel poor dummy(winter 2011–12)	0 (n = 399, 88.3%)	1 (n = 53, 11.7%)		0
Q48HEATHRS1	Hours of heating (winter 2010–11)	0.570	24	6.90073	4 (n = 83)
Q49HEATHRS2	Hours of heating (winter 2011–12)	0.570	24	5.92486	4 (n = 86)
KWHM2TOTAL1	Actual specific energy consumption (kWh/m^2, winter 2010–11)	0.0351695	882.793	134.034	82.1642 (n = 8)
KWHM2TOTAL2	Actual specific energy consumption (kWh/m^2, winter 2011–12)	0.0351695	676.798	114.172	90.1362 (n = 7)
KWHM2DEGRD	Specific energy consumption based on degree days (kWh/m^2, winter 2010–11)	0.0474425	1190.86	182.404	110.837 (n = 6)

houses it equaled 120.5 m^2. The mode (i.e. most frequent value) of surface area was equal to 120 m^2 for both subsets i.e. apartments and detached houses (and was valid for a total of 56 households). The median floor for apartments was 2 with a mode of one (valid for 136 apartments). Households had one to 8 members, with an average household size of 3.5 (and mode of 4) in the case of detached houses and an average of 2.8 (with a mode of 2) in the case of apartments. These figures corresponded to an average of 37 m^2 per household member (and a mode of 30 m^2 which was valid for 50 households) with no difference between apartments and detached houses.

The effect of the global financial crisis and resulting austerity measures in Greece is depicted in the average household income that was reduced from 26,221 euros (2009), to 24,900 euros (2010) and 22,498 euros (2011), a total reduction of 14%. Changes in the distribution of annual household income are shown in Fig. 2.

Household income changes were different across income classes as shown in Table 2.

Interestingly, the lowest income class gained about a fourth of its 2009 income probably because more household members joined the work force due to the worsening economic conditions. All other classes lost 12.7–31% of their 2009 income.

Looking at heating sources for the (colder) winter of 2011–12, it was found that: 18 households (3.1% of the total) did not use oil, natural gas or air conditioning; 141 households (24.3%, i.e. about one in four) were heated with oil alone; 29 households (5%, i.e. one in twenty) used only natural gas; and 51 households (8.8%) employed only air conditioning. Turning to mixtures of energy sources, it was found that: 309 households (53.2% of the total) were heated with oil and air conditioning; natural gas with air conditioning was by

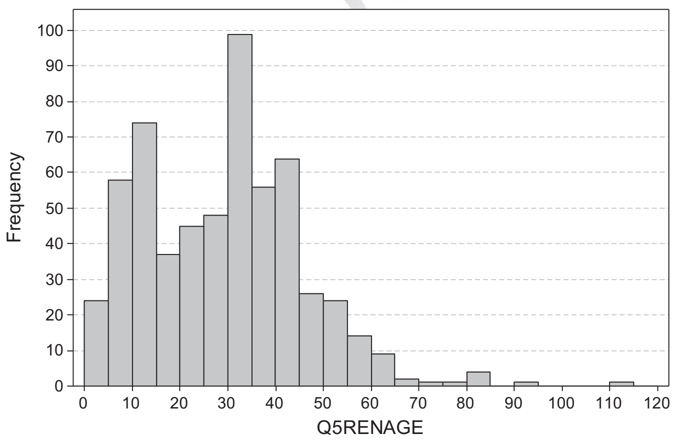

Fig. 1. Building age (since construction or last renovation).

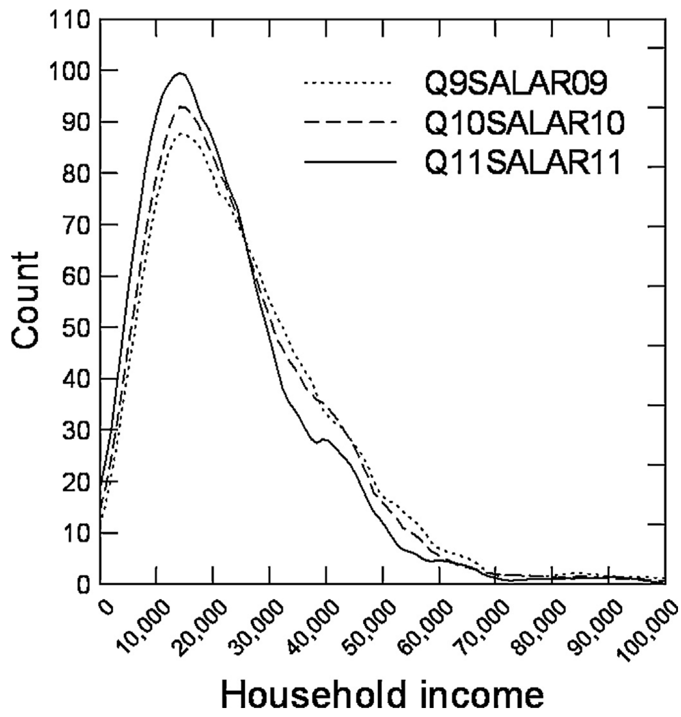

Fig. 2. Annual household income distribution (2009–2011).

Table 2
Household income changes across income classes.

2009 income (thousands of euros)	Income change until 2012 (euros)	% change relative to average 2009 income in class
0–10	+1682	+26.1
10–20	−1778	−12.7
20–30	−3539	−15.1
30–40	−5056	−15.4
40–50	−5545	−13.2
50–60	−9496	−18.5
60–70	−8615	−14.2
70–80	−21,667	−31.0
80–90	−19,400	−23.4

used by 32 households (5.5%); finally, only one household apparently had the opportunity to use all three heating sources (oil, gas and air conditioning). In the previous winter, 2010–11 (that was warmer), only 40 households (6.7% of the total) declared a different heating source; of these, 17 (2.8%) changed from oil to natural gas. In the 405 households (67.7% of the total or three out of four) that had air conditioning, the number of units varied from one to 7 with 9000 BTUs (2.64 kW) being the most prevalent unit type; three-fourths (74.4%) of the households had up to two units with 2 units being the mode (valid for 131 households). On the average, households with air conditioning turned on their unit(s) for 3.8 h daily and when the temperature fell below 17.3 °C. Finally, 280 households (71.6% of the 391 that had air conditioning) did not use their units at night.

Based on the consumption of the first (milder) winter and degree hours of the second (colder) winter, specific energy consumption in the second winter should have an average of 182.40 kWh/m^2 and a median of 138.40 kWh/m^2. Yet, the average specific consumption of the second winter equaled 114.17 kWh/m^2 (with a median of 88.052) so it more than a third (37.4%) smaller than expected. Breaking specific energy consumption by income class, shown in Table 3, shows that specific energy consumption in the second winter (2011–12) was up to 20.9% smaller than the first (2009–10) and up to 72.1% smaller than what was expected been based on degree hours.

Energy consumption in the first (milder) winter (2010–11) varied from 0 to 883 kWh/m^2 with an average of 134 and a median of 102 kWh/m^2; 12 large values varying from 514 to 883 were retained in the analysis because they appeared to be correct. Energy consumption in the second (colder) winter (2011–12) varied from 0 to 676 kWh/m^2 with an average of 109.6 and a median of 88 kWh/m^2; again, 5 large values (567 to 677) were nevertheless correct and were retained in the analysis. Households used an average of 20.1 kWh/m^2 less energy in the second winter (a 15% reduction) despite the fact that it was colder.

As mentioned in the literature review section, if the Fuel Poverty Ratio (FPR) is greater than 0.1, the household is considered to be fuel poor [4]. Two FPRs were calculated, based on fuel expenses for the winters of 2009–10 and 2010–11 and the household income of the years 2010 and 2011. Average FPR was 0.05 for the 2009–10 winter and 0.055 for the 2010–11 winter, with the second value being bigger than the first at a significance level higher than 99.99% (t-test for paired samples: $t = 2.620$; $p = 0.0045$). It is concluded that the fuel poverty of households deteriorated very significantly during the duration of the study. The ratio of fuel poor households was 11.1% (52 cases) for the first winter and 11.7% for the second (53 cases). These figures underline the importance of fuel poverty in Greece during this time of global financial uncertainty.

In the 452 apartments (75.6% of the total) that had an average age of 27.8 years and an average surface area of 88.69 m^2, dwelled an average of 2.82 persons, with an average three-year (2010, 2011 and 2012) household income of 23,034 euros and an average energy consumption of 124.8 kWh/m^2 in the first winter (2010–11) and 103.4 kWh/m^2 in the second winter (2011–12), i.e. a reduction of 17%. In comparison, in the 146 detached houses (24.4% of total households) that had an average age of 31.3 years and an average surface of 120.5 m^2, dwelled an average of 3.5 persons, with an average three-year household income of 27,126 euros and an average energy consumption of 163.1 kWh/m^2 for the first winter and 148 kWh/m^2 for the second winter (a reduction of 9.3%). It is worth noting that the bigger reduction that is observed in apartments may be (in part) due to the more accurate measurement of energy consumption in detached houses.

More interesting comparisons are presented in the next section that documents the clustering of households into a low and a high income group.

4.2. Cluster analysis

To achieve a distinct clustering of cases, a relatively small number of variables (representing salient features of households) should be included in the analysis. Of the many variables available, those (a) holding data considered to be of high quality and (b) having only a handful of missing values were considered for cluster analysis (so that a listwise deletion of cases with missing data would not result in a dramatic reduction of cases available for clustering). Data quality and missing data consideration along with a priori expectations as to which variables should characterize the profile of a household, lead to the following variables being selected for possible inclusion in cluster analysis:

- socioeconomic (Q9SALAR09/Q10SALAR10/Q11SALAR11, Q3MEMBERS);
- building related (property type, i.e. apartment/house, Q5RENAGE, Q4M2);
- energy consumption related (Q12OIL, Q13GAS, Q14AC, Q31CONSERV, Q48HEATHRS1/Q49HEATHRS2, KWHM2TOTAL1/KWHM2TOTAL2);
- environmental (DEGRDAYRATIO) variables.

Fuel poverty ratio information, in particular, could not be included in the analysis due to more than 150 missing values.

Prior to the analysis it was noted that some quantitative variables measured the same quantity at different times and were thus highly collinear. Retaining all such variables in the analysis would result in their overrepresentation [54]. On the other hand, extracting factors from such variables (via factor analysis) may result in several problems and is advised against by Dolnicar and Grun [55] with arguments that are valid in the case of principal component analysis as well. Based on these recommendations, it was decided that:

- only the 2011 income (Q11SALAR11) with the 2011–2009 income reduction (DIFFSALARY) be retained in the analysis, as the smallest number of income variables that still convey a measure of (a) income size and (b) income reduction due to the financial crisis;
- only the difference in heating hours (DIFFHEATHOURS) between the two winters be selected for inclusion in the analysis;
- energy consumption be represented by (a) the specific energy consumption of the second (harsher) winter (KWHM2TOTAL2) and (b) its difference from the specific consumption (of the same winter) expected from degree hours (DIFFKWHM2DEGRD).

Trying different two-step clustering schemes (carried out with IBM SPSS version 21) with the categorical variables (such as property type, Q12OIL and Q31CONSERV) included, showed that no stable number of clusters could be reached at. Dummy variables

Table 3
Specific energy consumption per income class.

2009 income (thousand euros)	Median consumption 2010–11 (kWh/m^2)	Median consumption 2011–12 (kWh/m^2)	Was reduced by (%)	Expected consumption 2011–12 (kWh/m^2)	Should be bigger by (%)
0–10	115.06	102.41	−11.0	156.84	53.1
10–20	127.57	110.06	−13.7	173.53	57.7
20–30	140.52	118.25	−15.8	191.24	61.7
30–40	165.41	130.88	−20.9	225.29	72.1
40–50	127.33	109.47	−14.0	173.61	58.6
50–60	123.85	115.01	−7.1	168.26	46.3
60–70	160.78	134.70	−16.2	217.19	61.2
70–80	202.25	166.41	−17.7	272.83	64.0
80–90	184.13	177.49	−3.6	248.99	40.3

were found to exert an undue amount of influence in shaping the number and size of the clusters; when one relatively unimportant dummy variable (such as Q13GAS) was taken out, an entirely different number of clusters of different size resulted. Much stabler clustering schemes were obtained when only quantitative variables were included in the analysis and hierarchical clustering was used.

On the issue of sample size, Formann [56] as quoted by Mooi and Sarstedt [54] recommends a sample of at least 2^m cases, where m equals the number of clustering variables. Although these are just recommendations, it follows that it would be good to not exceed 8 (sample size of 256) to 9 (sample size of 512) variables in order to cluster analyze the available 598 cases (not all of which will be complete).

The final list of 8 variables included in hierarchical cluster analysis along with complete cases is shown in Table 4.

It was decided that hierarchical cluster analysis be carried out with Ward's linkage method and the squared Euclidean as the appropriate distance measure [57]. On the number of clusters, some exploratory graphs (Figs. 1 and 2) had previously indicated the presence of two clusters [58], a scheme that was confirmed by the analysis. The presence of two clusters was validated by rerunning the analysis on randomly sorted data [54] and is shown in Table 5.

The 508 complete cases were classified into two clusters:

1. The first cluster included about three-fourths (76.6%) of the cases and evidently represented lower-income households. These had a 2011 income of 18,006 euros, 4355 euros lower than their 2009 income; had 2.8 members per household; lived in an apartment of a house with an area of 83.2 m^2, in a building that was 30.5 years old (or last renovated); and had a specific energy consumption of 131.5 kWh/m^2 for the second (harsher) winter, a full 76.6 kWh/m^2 lower than expected from climatic conditions (degree hours);
2. The second cluster included the rest one-fourth (23.4%) of the cases, that represented higher-income households. These had a 2011 income of 39,744 euros (more than twice the income of the first cluster), that was only 2174 euros lower than their 2009 income; had 3.7 members per household, one more than the previous cluster; lived in an apartment of a house with an larger area of 136.3 m^2, in a building that was only 21.8 years old (or last renovated); and had a lower specific energy consumption of 102.4 kWh/m^2 for the second winter, 54.6 kWh/m^2 lower than expected from climatic conditions.

As noted by the t-tests for independent samples (with equal or unequal sample variances assumed as indicated by Levene's test) in the rightmost column of Table 5, all variable values at the cluster centroids were significantly different between the two clusters at a confidence level of 97% or higher. This provides an initial confirmation of the validity of the classification of households in two distinct clusters. Further validation is provided by comparing the values of other criterion variables at the cluster centroids – these are provided in Table 6, the last column of which tests indicates the results of independent sample t-tests or proportion z-tests (as appropriate).

It is seen that:

- the income of Cluster 2 (higher income) is twice that of Cluster 1 (lower income) and that even the per capita income is different between the two clusters at a confidence level higher than 99.99%;
- twice (i.e. 39.5%) the number of households of Cluster 2 live in houses compared to those of Cluster 1 (i.e. 19.54%) and this also reflects on the value of Q7FLOOR;
- more Cluster 2 households (15.97%) are heated with natural gas and have more installed air conditioning power (30,410 BTU) compared to those of Cluster 1 (9.95% and 23,953 BTU respectively);
- one out of three Cluster 1 households (i.e. 35.6%) adopted some conservation measures after the first winter, compared to one out of four for Cluster 2 (24.79%);
- only 2.06% of the households of Cluster 2 households were above the fuel poverty line, compared to 13.87% for Cluster 1;
- finally, Cluster 2 households consumed less specific energy in the first winter as well (115.4 kWh/m^2 compared to 145.1 for Cluster 1).

Table 4
Variables used in cluster analysis.

	Variable	Complete cases	Range
1	Q11SALAR11	585	0 to 200,000
2	DIFFSALARY (=Q11SALAR11 – Q11SALAR9)	579	−80,000 to 40,000
3	Q3MEMBERS	596	1–8
4	Q5RENAGE	588	2–112
5	Q4M2	597	25–400
6	DIFFHEATHOURS (=Q49HEATHRS2 – Q49HEATHRS1)	563	−22.5 to 20.0
7	KWHM2TOTAL2	560	0.0352–676.798
8	DIFFKWHM2DEGRD (=KWHM2TOTAL2 – KWHM2DEGRD)	558	−757.463 to 364.833

Complete cases after listwise deletion of missing data: 508.

Table 5
Cluster centroids (eq. var., equal variances *t*-test; uneq. var., unequal variances *t*-test).

	Variable	Cluster 1 (“low income”)	Cluster 2 (“high income”)	*t*-test H_0: $\mu_1 = \mu_2$ H_a: $\mu_1 \neq \mu_2$
1	Q11SALAR11	18,006	39,744	$t = -9.18$; $p = 0.0000$ (uneq. var.)
2	DIFFSALARY	−4355	−2174	$t = -2.52$; $p = 0.0120$ (eq. var.)
3	Q3MEMBERS	2.8	3.7	$t = -7.16$; $p = 0.0000$ (eq. var.)
4	Q5RENAGE	30.5	21.8	$t = 6.32$; $p = 0.0000$ (uneq. var.)
5	Q4M2	83.2	136.3	$t = -13.82$; $p = 0.0000$ (uneq. var.)
6	DIFFHEATHOURS	−1.3	−0.3	$t = -3.29$; $p = 0.0010$ (eq. var.)
7	KWHM2TOTAL2	120.7	102.4	$t = 2.28$; $p = 0.0234$ (uneq. var.)
8	DIFFKWHM2DEGRD	−76.6	−54.6	$t = -3.22$; $p = 0.0014$ (uneq. var.)
	Cases in cluster	389 (76.57%)	119 (23.43%)	

Table 6
Values of selected criterion variables at cluster centroids (eq. var.: equal variances *t*-test; uneq. var.: unequal variances *t*-test;.

Variable	Cluster 1 (“low income”)	Cluster 2 (“high income”)	*t*- or *z*-test: H_0: $\mu_1 = \mu_2$ H_a: $\mu_1 \neq \mu_2$
Q9SALAR09	22,361	41,918	$t = -7.96$; $p = 0.0000$ (uneq. var.)
Q10SALAR10	20,707	41,865	$t = -8.38$; $p = 0.0000$ (uneq. var.)
Income per household member (SAL11PCAP)	7638.69	12,590.8	$t = -5.42$; $p = 0.0000$ (uneq. var.)
% of households dwelling in house	19.54%	39.50%	$z = -4.45$; $p = 0.0000$
% of households dwelling in apartment	80.46%	60.50%	$z = 4.45$; $p = 0.0000$
Q7FLOOR	1.8	1.5	$t = 1.70$; $p = 0.0906$ (eq. var.)
Q13GAS	9.95%	15.97%	$z = -1.81$; $p = 0.0710$
Q16BTU	23,953	30,410	$t = -3.14$; $p = 0.0022$ (uneq. var.)
Q17TEMP	17	18.4	$t = -1.56$; $p = 0.1200$ (eq. var.)
Q18HOUR	4.01	3.46	$t = 1.49$; $p = 0.1398$ (uneq. var.)
% of households that took conservation measures (Q31CONSERV)	35.60%	24.79%	$z = 2.17$; $p = 0.0297$
DIFFTEMPIN	−0.54	−0.4	$t = -1.05$; $p = 0.2943$ (uneq. var.)
DIFFTEMPOUT	−0.69	−0.59	$t = -0.55$; $p = 0.5836$ (uneq. var.)
FUELPOVRAT1	0.055	0.033	$t = 5.02$; $p = 0.0000$ (uneq. var.)
% of households above fuel poverty line (2010–11) (FUELPOOR1)	13.87%	2.06%	$z = 3.24$; $p = 0.0012$
FUELPOVRAT2	0.061	0.040	$t = 4.18$; $p = 0.0000$ (uneq. var.)
% of households above fuel poverty line (2011–12) (FUELPOOR2)	14.71%	3.06%	$z = 3.10$; $p = 0.0019$
Q48HEATHRS1	6.9	7.1	$t = -0.33$; $p = 0.7408$ (eq. var.)
Q49HEATHRS2	5.6	6.8	$t = -2.27$; $p = 0.0244$ (uneq. var.)
KWHM2TOTAL1	145.1	115.4	$t = 3.22$; $p = 0.0014$ (uneq. var.)

Many of these findings are in agreement with Santamouris et al. [38].

Cluster analysis is thus brought to conclusion, having obtained a clear picture of the classification of households: one out of four household is of higher income that suffered a smaller loss since 2009; has more members; lives in a newer and larger house or apartment; and consumes less specific energy. It is the other three in four households that fuel poverty policies should target so that the 13.9% fuel poor proportion of this group is controlled even if the economic crisis in Greece deepens.

5. Conclusions

The survey presented in this paper focused on Greece and analyzed the energy consumption of households located in a wide variety of geographical regions and bioclimatic types. Many of the findings are in agreement with Santamouris et al. [38]. Clearly, the lower-income three out of four households are the ones that fuel poverty policies should target, so that the 13.87% fuel poor proportion of this group is controlled as best as possible, given the financial crisis in Greece. Energy policies should take into account social consequences so as to avoid causing further human misery [7]. Energy counseling together with energy saving packages for emergency relief (e.g. energy saving bulbs, radiator reflectors), pointed out by the French survey reviewer earlier, would help in this direction.

As regards the means, in Ireland, fuel allowance does reduce the severity of experience of fuel poverty among the low-income households. As pointed out by Kelly [18], homes with a propensity to consume more energy should be targeted using behavioral strategies combined with economic penalties and incentives; homes with low Standard Assessment Procedure (SAP) rates should be targeted for whole home efficiency upgrades in order to break through the energy efficiency barrier. The (SAP) is the methodology used by the Department of Energy & Climate Change (DECC) in UK which assesses and compares the energy and environmental performance of dwellings. In Greece, Santamouris et al. [38] concluded that energy policies addressed to the dwelling sector should set as a priority the improvement of the envelope quality of residents where low income people are living.

One should be beware of the economic means though, especially at this time of great financial crisis and hardship in Greece. The consequences of a liberal energy market without any regulations regarding the prevention of energy debts may be seen in Austria [26]. All the measures suggested should be integrated into a national strategy for the reduction of fuel poverty. The Austrian study suggests all proposed measures not be applied singularly but instead be integrated into a national strategy for the reduction of fuel poverty.

The UK Department of Energy (DOE) has claimed that the achievement of energy conservation together with affordable warmth are the two central aims of efficiency policies and even the slightest improvement in energy efficiency would help in providing affordable warmth to the poorest households [16]. The importance of this study is further underscored by the fact that the building sector in Greece represents 36% of total energy consumption and consumes around 450 million euros per year [49].

Turning to directions for further study, an important task that complements the present study is the monitoring of low income households with sensors in order to investigate temperature levels for the case of families that can barely purchase heating energy. This research is underway by some of the authors of this paper and its results are expected to shed more light on the relationship between energy and poverty and how these affect survivability at this time of a global financial crisis. Other tasks that would be beneficial to carry out in a future investigation include: collection and analyses of more household data from Northern Greece, an in-depth comparison of apartments versus detached houses, the impact of specific energy conservation measures adopted by households, and an examination of alternative policies designed to address fuel poverty in Greece and Southeastern Europe.

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