Understanding fuel expenditure:

Fuel poverty and spending on fuel

A report to Consumer Focus from:
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Acknowledgements

Introduction

The Government has commissioned Professor John Hills to carry out an independent review of the fuel poverty definition and target in England. The review team published its interim report in October 2011 and is due to publish its final report in January 2012. Consumer Focus recognises the importance of the Hills review to fuel poverty policy. Our contribution to the review is a key priority for our fuel poverty work in 2011/12.

Consumer Focus wanted to get a better understanding of consumers' expenditure on fuel and how this affected our understanding of fuel poverty. We have long recognised that low income consumers tend to either:

- cut back on fuel expenditure, and as a result suffer cold homes, or
- try to maintain fuel expenditure and then either go into fuel debt or forego expenditure on other essential goods and services

We therefore commissioned the Centre for Sustainable Energy and Donald Hirsch of Loughborough University to investigate these issues further, particularly with respect to the relationship between consumers' actual fuel expenditure and so-called 'required fuel expenditure'.

The concept of 'required fuel expenditure' – the amount of expenditure required to maintain adequate temperatures in the home and meet other energy needs – is central to the definition of fuel poverty. This states that a household is in fuel poverty if its 'required fuel expenditure' is 10 per cent or more of household income. It is also central to other important Government policies. For example, the Green Deal's 'golden rule' is designed to make sure estimated energy bill savings, resulting from the installation of energy efficiency measures, exceed the Green Deal charge on consumers' fuel bills. But this calculation is based on 'required fuel expenditure', not the amount consumers actually spend.

We consider that the research CSE and Donald Hirsch have carried out makes an important contribution to our understanding of fuel poverty, particularly with respect to how low income consumers respond to high fuel prices. The research also sheds light on the relationship between fuel poverty and income poverty – a central issue for the Hills review. We consider that the findings should help both inform the next stage of the Hills fuel poverty review and future fuel poverty policy.

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Executive Summary

The Warm Homes and Energy Conservation Act 2000 required the Government to publish within a year a strategy setting out policies to ensure that as far as reasonably practicable no-one lives in fuel poverty. In 2001, the Government published the UK Fuel Poverty Strategy. With respect to England, the strategy set an interim objective of eradicating fuel poverty in vulnerable households as far as reasonably practicable by 2010; under the terms of the Warm Homes Act, no household should be in fuel poverty as far as reasonably practical by 2016.

Fuel poverty in the UK is currently measured by considering the proportion of income a household **needs[1]** to spend on energy in order to heat their home adequately. Using a theoretical measure of this type, rather than the amount people actually do spend, provides a valuable measure of a household's resources relative to need (an indicator of "capabilities"). It is unaffected by the actual decisions households make, which can be influenced by individual tastes and priorities.

Yet a full understanding of fuel poverty requires information about **actual** spending on fuel. Where heating costs are high relative to income, do people under heat their homes, or do they make sacrifices in other areas of spending in order to keep warm? Knowing these outcomes of fuel poverty would show the impact of low income and hard-to-heat homes on different groups.

There is growing interest in measures that estimate fuel consumption as part of improving our understanding of fuel poverty. For example, the government is developing a new data framework that involves direct use of fuel supplier data on household energy consumption. At the same time, the Centre for Sustainable Energy, working with the Universities of Bristol and Oxford, and with funding from the Joseph Rowntree Foundation, has been refining a sophisticated tool that combines data from different surveys into a single, unified dataset to enable comparisons of fuel usage, fuel need and income. The analysis presented in this paper utilises this new resource to estimate the consequences of fuel poverty for actual spending on fuel by low income households. This is the first time these variables have been examined together in this detail.

The analysis focuses on two questions:

1. How many people in fuel poverty under-consume fuel, with risks to their health and well being from having cold homes?
2. How many households have spending on fuel that is high relative to their incomes, potentially putting pressure on the rest of their household spending?

In both cases, a crucial issue is the extent to which these phenomena are experienced among people in fuel poverty and/or on low incomes. Thus, the analysis differs from one based only on the percentage of income that households need to spend on fuel. It distinguishes those where this percentage is high largely because their homes are expensive to heat from those where a high ratio is driven by low income.

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[1] [1] The definition of fuel poverty is based on a theoretical requirement for a household to spend more than 10% of its income on all fuel to heat its home to an adequate standard of warmth. This is generally defined as 21°C in the living room and 18°C in other occupied rooms.

Main results

a) A comparison of **actual fuel consumption with fuel need** shows that, in general, households consume substantially less fuel than the requirement calculated from the 2007 English House Condition Survey. On average, households consume only around two thirds of "need", and across all income groups at least 80% consume "too little". Both fuel need and fuel consumption rise with income.

b) Analysis of **under-consumers of fuel** points to two main groups. People on low incomes are more likely than average to have consumption much lower than need, even though they do not on average have high needs: their under-consumption is driven by their low incomes. The other group is households in the top income decile, many of whom have large homes measured by floor area. Single people, both pensioners and non-pensioners, are more likely to under-consume than other groups, particularly if they are on low incomes or have hard to heat homes. Groups less likely to under-consume include families with children, people living in purpose-built flats and those living in social housing.

c) Analysis of households who spend **a relatively high proportion of income** on fuel shows that this is more closely associated with low income than high fuel requirements. It also affects some groups more than others. For example, lone parents, whose income tends to be low, are particularly likely to spend a large part of their incomes keeping warm, putting pressure on their overall standard of living. Among households without children, high relative fuel spending is higher for singles than for couples, and highest for singles under 60.

d) The risk of **under-consumption** is more closely linked to fuel poverty than overall poverty; according to a comparison with income poverty and income adequacy. In the case of **high relative spending** on fuel, on the other hand, the reverse is the case: those who have low incomes overall are much more likely to spend a high proportion of income on fuel, whether or not their fuel needs are high relative to income. Single people under 60 also spend a relatively high percentage of income on fuel.

Overall, these results suggest that fuel poverty creates different kinds of risk for different groups Families with children are least likely to under-consume. However, keeping warm can put pressure on their overall standard of living: lone parents, whose income tends to be low, are particularly likely to spend a large part of their incomes on fuel. On the other hand, single people, both on low incomes and with higher incomes but hard to heat homes, are particularly likely to under-consume fuel, resulting in potential risks to their health. Single people under 60 face the dual risk of having low consumption relative to need and having high average fuel spending relative to income.

The implication for policy is that a multifaceted approach to tackling fuel poverty is required. Different policy responses are therefore needed to address the challenge of fuel poverty for different consumer groups. These responses should be informed by the two indicators of outcomes analysed here (under-consumption and high spending relative to income) as well as by the current fuel poverty indicator (high need relative to income).

The paper ends by commenting briefly on two aspects of future analysis. One proposes developing improved data in order to better understand different groups' expenditure on fuel. The other proposes further analysis of the definition of thermal comfort, given that the present definition does not describe anything that relates to contemporary norms. One approach may be to draw on subjective measures to explore the level at which people feel that their homes are too cold.

1 Background

Energy policy has typically used three broad approaches to analyse the distributional impacts of changing fuel costs on householders, namely:

1. **Fuel poverty based assessments**, whereby the impact of changing fuel costs and / or energy policy on the theoretical[2] need for heat and power in the home is assessed. For example, the energy needed to meet the fuel poverty criteria for comfort may be determined following the installation of measures and then used to calculate the theoretical fuel bill and thus the **impact of policies upon fuel poverty.**

2. **Expenditure based assessments,** which assess the impact of changing fuel costs and energy policy on the actual energy consumption of a household. For example, the true impact of measures to improve the energy efficiency of the housing stock can be assessed by looking at associated changes in household expenditure on fuel.

3. **Threshold based assessments**, which assess the impacts of establishing a minimum threshold for fuel expenditure as part of the wider need to maintain a reasonable standard of living. For example, the Minimum Income Standards (MIS) definition of poverty considers the need to purchase fuel alongside the other pressures on household budgets, for example food, clothing etc. While such assessments cannot accurately report on the individual fuel costs facing households whose homes require different amounts to heat satisfactorily, they help illustrate, with reference to a benchmark level of fuel spending, the changing impact of fuel prices on the burden of fuel spending within family budgets.

The relationship between a household's actual energy consumption and the theoretical need to use energy to heat and power a home is a critical one: households that have low actual consumption and high need are likely to be cold. Not since the 1996 English House Condition Survey (EHCS), where internal and external temperatures were recorded, has there been a unified dataset that contains both these values. The English Housing Survey (EHS) Follow-up Survey (2011-12) is collecting data on temperatures and consumption; however, the results of the survey will not be reported in time to inform the Hills fuel poverty review.

This paper uses a synthesised dataset of actual energy expenditure from the Living Costs and Food Survey (2004-07 data) and energy need from the (2007) English House Condition Survey (EHCS) to explore this relationship in more detail. The findings should help inform the development of fuel

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[2] The definition of fuel poverty is based on a theoretical requirement for a household to spend more than 10% of its income on all fuel to heat its home to an adequate standard of warmth. This is generally defined as 21°C in the living room and 18°C in other occupied rooms.

poverty policies. Recognising immediate policy and research requirements in the context of the Hills Review, this short research exercise aims to:

- Explore the extent to which people with low incomes have high actual fuel bills, thus putting a strain on their overall financial resources;
- Explore the extent to which fuel poor households spend too little to heat their homes adequately;
- Draw conclusions about the potential to produce a more powerful indicator of fuel poverty.

2   Methodology

2.1.   Developing the synthesised dataset

The Centre for Sustainable Energy (CSE), working with the Universities of Bristol and Oxford, has recently received funding from the Joseph Rowntree Foundation (JRF) to examine the social impacts of UK climate change policy. The study draws on data from four different surveys (the Living Costs and Food Survey (LCF); the National Travel Survey (NTS); Civil Aviation Authority Air Passenger Survey) to develop a unified dataset of GB carbon emissions for household fuels, road transport, public transport and aviation. Following a complex process of survey harmonisation and multiple imputation, the carbon emissions (CO_2) estimates for heat and power consumption in the LCF were imputed into the EHCS[3]. The resulting dataset provides a set of individual cases with the full spectrum of EHCS energy need and fuel poverty related data and carbon emissions based on actual household fuel consumption.

Linear regression analysis was then used to derive actual heat and power consumption (in kWh) from the heat and power CO_2 totals imputed to the EHCS from the LCF (as part of the aforementioned JRF study). This estimation of actual fuel consumption provides a modelled value that allows for the distribution in the donor survey, namely the LCF.

The team then calculated energy bills for actual consumption and energy need using CSE's DIMPSA[4] model. DIMPSA uses a series of algorithms and fuel price look-ups to estimate energy bills in 2011 based on given levels of fuel consumption. This was applied to both EHCS energy need and (LCF) imputed actual consumption data, thereby giving an estimate of baseline 'actual' energy bill and baseline energy 'need' bill. This dataset provides the basis for all analysis presented in this report.

Overall, with respect to both consumption and unit cost, the model imputes a range of spending values for any one set of EHCS characteristics, based on observed variation in actual usage and cost, rather than imputing a single spending level for a particular type of family living in a particular type of home.

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[3] For the JRF funded study the multiple imputation process drew on Rubin's work (1996). As such, plausible values for missing observations (the EHCS in this case) are created using a model that incorporates random variation. This is done several times (usually 5 times) and the plausible values are used to "fill-in" the missing values and create five "completed" datasets with no missing values. The JRF study used a Bayesian technique to allow for this random variation. The values of the intermediate parameter estimates are then averaged across the five samples to produce one single final point estimate.

[4] CSE, Distributional Impacts Model for Policy Scenario Analysis (DIMPSA) 2011

2.2.   Analysing energy consumption and expenditure

Using the dataset described above, this paper first presents some high level analysis of the distributions of energy need and actual consumption (in kWh and £) against key socio-demographic variables in the EHCS, including by income deciles and social/poverty indicators (e.g. vulnerability, fuel poverty etc).

Two fundamental concerns in fuel poverty policy analysis are the extent to which:

1) Households may have high consumption relative to income (and therefore be vulnerable to fuel price rises);
2) Households are under-heating and cold.

Previous research by CSE of LCF Survey data has identified a clear group of low income households that fall into the first category[5]. However, to date, the conclusions that could be drawn from this analysis were limited in terms of understanding the key factors driving high consumption (due to the lack of detailed housing condition data in the LCF Survey dataset).

This paper therefore aims to build on CSE's previous research and look more closely at this group by exploring the relationship between actual consumption and energy need. This will help to identify where high actual consumption is driven by need and the extent to which households are 'under-consuming' and may be cold.

Using a combination of energy need, energy consumption and data on incomes (measured after housing cost – AHC[6]), we also aim to identify and quantify households that have high energy need relative to income (i.e. the fuel poor) against those with high actual fuel consumption relative to income ('low income high users').

The analysis described above aims to provide a comprehensive picture of actual and required fuel spending relative to household income but does not allow for other pressures on the household budget. We have therefore undertaken further analysis to explore the relationship between household fuel requirements and spending to the overall adequacy of household income. As well as considering whether households are above or below the 'income poverty' line – using the 60% median income threshold – we consider incomes relative to an "adequacy" benchmark, the Minimum Income Standards (MIS), which represents a threshold of a minimum socially acceptable standard of living. MIS income is compared to the AHC measure of disposable income, as an indicator of whether households may experience difficulties making ends meet.

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[5] White, V., Roberts, S., & Preston, I. (2010). *Understanding 'High use, low income' energy consumers*. Report to Ofgem.
http://www.ofgem.gov.uk/SUSTAINABILITY/CP/CF/Documents1/High%20use%20low%20income%20energy%20consumers_Final%20Report%20Nov%2010.pdf
[6] After Housing Cost Income has been used here as it provides a better representation of peoples actual resources i.e. the income they can realistically spend on fuel.

3 Results

3.1. How does energy consumption compare to energy need, for people on different incomes?

Figures 1 and 2 consider, across income deciles, how actual consumption and energy spending compare to "need" as measured through the calculation of fuel requirements by the EHCS.

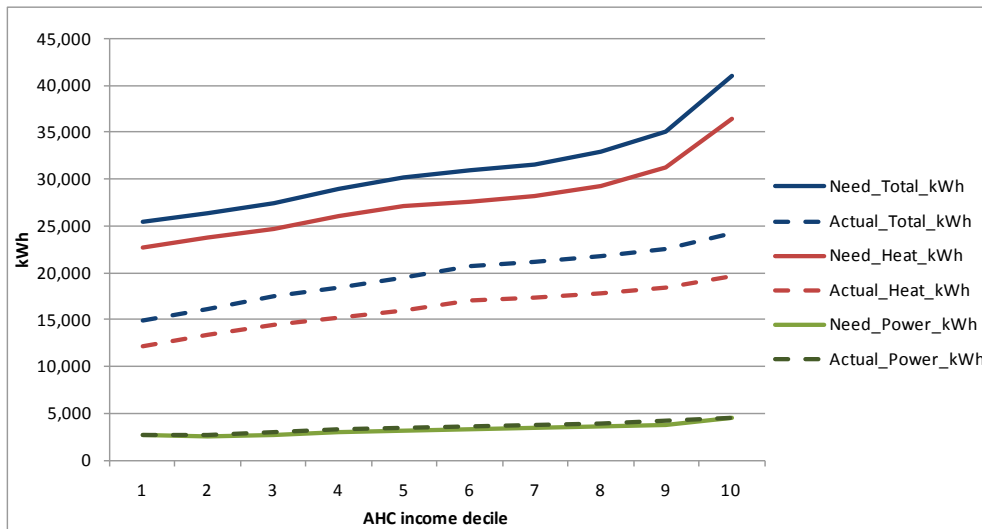**Figure 1: Mean annual 'need' and actual energy consumption (kWhs) by income deciles (AHC)**
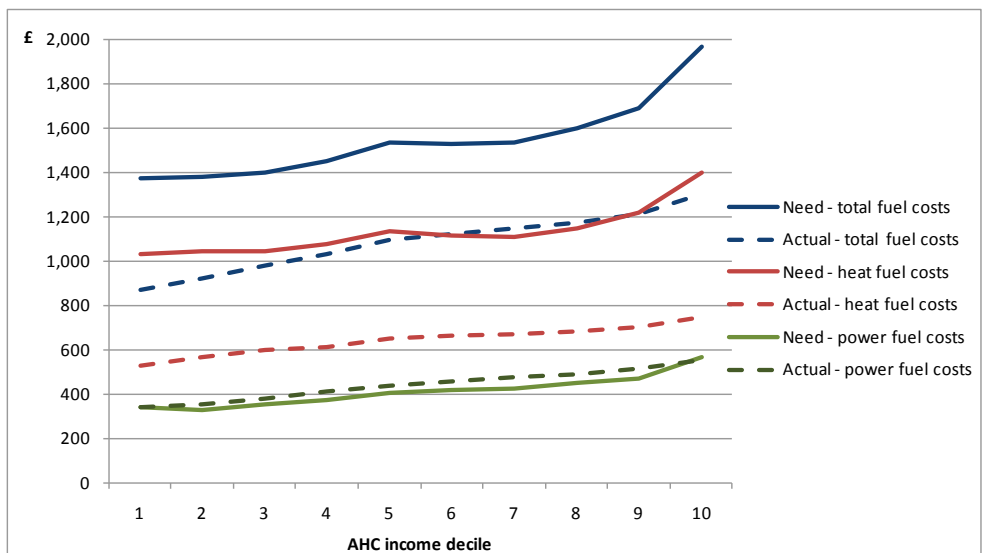

Figure 2: Mean annual 'need' and actual energy costs (£) by income deciles (AHC)

The graphs show that average spending on power rises with income, and that this rise corresponds with a rise in average power "need" with income. However, mean actual annual heat (and total) energy consumption is significantly lower than the estimated level of need for all income deciles: the lowest income decile consumes some 10,000 kWh less than the estimated need value on average, whilst this differential increases to over 15,000 kWh for the highest income decile.

Overall, there is only a modest correlation between need and actual heat consumption: regression analysis (with outliers removed) gives an $R^2 = 0.185$; therefore over 80% of the variance in actual heat consumption can be explained by factors other than energy need.

Annex I contains a set of additional graphs showing 'need' and actual annual energy consumption (in kWh) against a range of socio-demographic variables. The charts replicate the trend for under-consumption of both heat and total energy consumption. However, interestingly, the difference in the two consumption values tend to be narrower for households in purpose built flats and those in socially rented properties, where the energy need values are typically lower. The same trend is evident for the age of property which is also a key driver for a set of assumed efficiency settings in the model of energy need.

Figure 1 above shows a clear positive correlation between energy consumption (both actual and need) and income. However, as illustrated in Figures 3 and 4, the mean values mask much within-decile variation. For example, there are a number of households in the lowest income deciles with above average need and actual heat consumption[7].

Figure 3: Within income deciles distribution of heat need and actual consumption
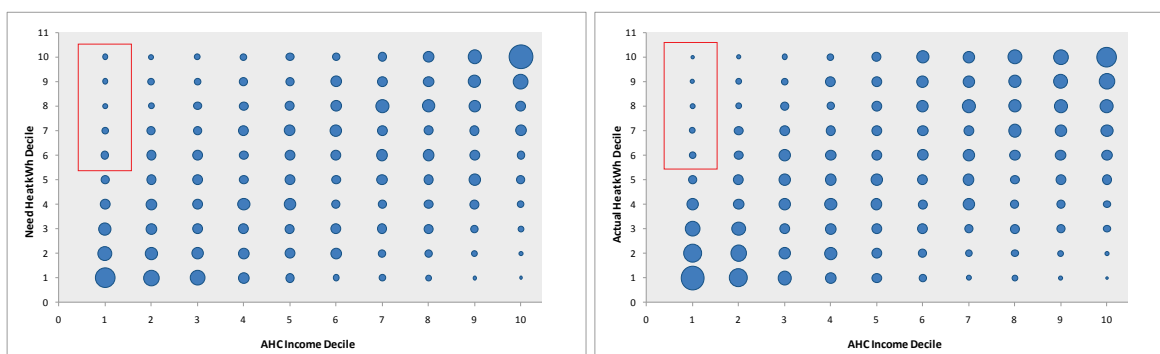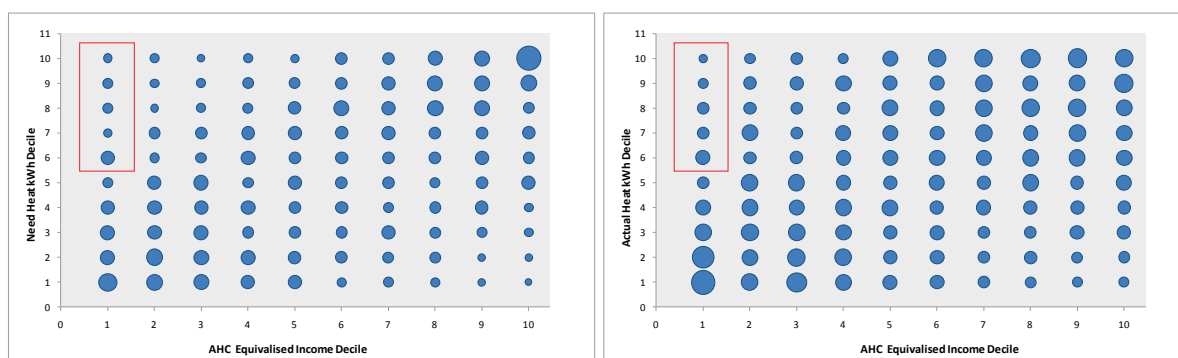

Figure 4: Within equivalised income deciles distribution of heat need and actual consumption

There appears to be a slightly stronger correlation between un-equivalised income and actual consumption than 'need', with a less pronounced pattern in both cases when incomes are equivalised. Linear regression analysis of (AHC) income against heat energy consumption and heat

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[7] For further analysis and discussion of low income high energy consumers see: White, V., Roberts, S., & Preston, I. (2010). *Understanding 'High use, low income' energy consumers*. Report to Ofgem. http://www.ofgem.gov.uk/SUSTAINABILITY/CP/CF/Documents1/High%20use%20low%20income%20energy%20consumers_Final%20Report%20Nov%202010.pdf

energy need (with the outliers removed) provides further evidence of this relationship, with an R^2 of 0.12 for actual heat consumption and 0.09 for 'need' heat consumption.

The examination of energy consumption and energy need highlights the following key conclusions:

- Lower income households have lower energy 'need' and lower actual consumption, on average, than higher income households.
- Income is a better predictor of actual energy consumption than estimates of need.

Furthermore, all income deciles appear, on average, to consume less than the estimated level of heat (and total) energy need (Figure 1). Figure 5 provides a cross-tabulated count of households in each actual and need heat consumption decile. If *relative* estimates of heat 'need' and actual consumption were aligned, we would expect households to fall within the area outlined within the 'red circle'[8]. Whilst the majority do, there are significant numbers of households that have a higher heat consumption relative to need (i.e. sit within the top left of the graph) or lower actual consumption relative to need (i.e. 'under-consuming', sit to the lower right of the circle).

Figure 5: Distribution of heat need and actual heat consumption by income decile
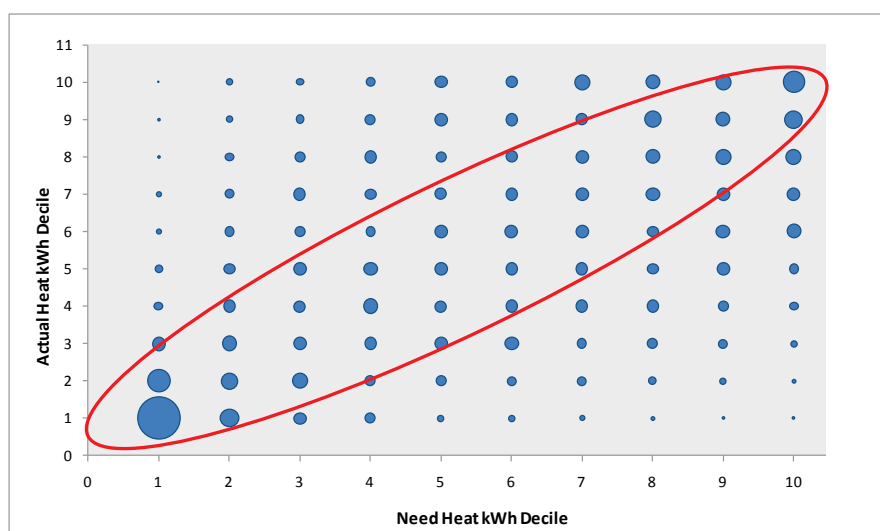
Note in particular that while the tenth of households with lowest need are particularly likely to be in the lowest tenth of consumers, there is a much weaker correspondence between the highest tenths by need and consumption (i.e. the bottom left dot is much larger than the top left). This suggests that while very few people with very easy to heat homes substantially over-consume fuel, considerable numbers with hard-to-heat homes under-consume.

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[8] This represents a relative measure as the mean kWh values of 'actual heat' and 'need heat' deciles do not correspond. For example, the mean value of actual heat decile 1 is around 6,200kWh compared to 9,900kWh for need heat decile 1. Thus a household may fall into actual consumption decile 1 and need decile 1, but they are still likely to be under-consuming – see table 1 in Annex 1.

3.2. Quantifying vulnerable high- and under- consumers

3.2.1. Low fuel consumption relative to need ('under-consumers')

Research has sought to understand better the drivers of under-consumption in households. For example, the research study, 'You just have to get by[9]', surveyed and interviewed households in income poverty (less than 60% median income) about their experience of managing household energy bills. The results showed that those on the very lowest incomes (less than £6,000 per year) were especially likely to have found their fuel bills to be a financial burden (50 per cent had done so), to have cut back on heating in the previous year (46 per cent), and to have lived in homes that were colder than they wanted them to be during the previous winter (63 per cent).

Analysis presented thus far in this paper suggests that on average, households under-consume (regardless of income), but there appears much within-decile variation of actual and need consumption. To focus on the main areas of divergence and the energy use most associated with experienced thermal comfort, the team has explored a 'consumption ratio' (CR), which represents actual heat consumption as a proportion of need-based estimates of heat consumption, i.e.:

Consumption ratio (CR) = $\dfrac{\textbf{Actual Heat Consumption (kWh)}}{\textbf{Need Heat Consumption (kWh)}}$

Table 1: Descriptive statistics for energy (overall, whole dataset)

	Mean	Median
Actual Power (kWh)	3,525	3,302
Need Power (kWh)	3,289	2,955
Actual Heat (kWh)	16,153	15,202
Need Heat (kWh)	27,698	25,594
Actual Total (kWh)	19,678	18,781
Need Total (kWh)	30,986	28,851
Consumption ratio	.68	.60

Table 1 shows the mean consumption ratio to be 68% for the entire dataset i.e. the average household consumes substantially less heat than their estimated level of need. The BREDEM model of required energy therefore systematically estimates the amount of energy needed by householders at a level substantially higher than the contemporary norm of consumption, in terms

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[9] Anderson, W., White, V. and Finney, A. 2010. "*You just have to get by*" Coping with low incomes and cold homes. A report to Eaga Charitable Trust: www.cse.org.uk/projects/view/1148

of what the average household consumes[10]. The predominant drivers for this may be a combination of: the demand temperatures in BREDEM; the occupancy settings; and the accuracy of the algorithm itself.

This has important implications for policies such as the Green Deal. The Green Deal assessment will use a BREDEM based (via Enhanced RD-SAP) energy assessment to model the financial viability of a package of measures. Integral to the assessment is the 'golden rule', whereby energy bill savings from energy efficiency packages are larger than the Green Deal finance charge. Thus, Green Deal assessments may suggest that potential energy bill savings are likely to be larger than those realised in practice. In effect, the 'golden rule' may not be very helpful in guiding consumers' decisions on whether or not to invest in energy efficiency.

Evidence from the PAYS pilots[11] suggests a degree of consumer goodwill with respect to the integrity of the 'golden rule', if they are happy with the standard of works and feel they paid a fair price. However, these households typically represent those with higher incomes and as such may not be reflective of lower income households with higher levels of debt aversion.

The minority of households, 15% as shown in table 2 below, have actual heat consumption greater than or equal to the estimated level of consumption needed to heat their property - and this ratio is similar across the income distribution. This is further illustrated by the histograms of the consumption ratio (see figures 6 and 7 below).

Table 2: Descriptive statistics for energy (overall, whole dataset)

	Count (HHs)	N %	Mean	Median	Minimum	Maximum
Actual heat >= Need	3,312,698	15%	1.32	1.22	1.00	3.91
Actual heat < Need	18,067,379	85%	.56	.54	.05	1.00

Figure 6: Histogram of consumption ratio

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[10] It is important to note that some households (e.g. people with some disabilities or illnesses) will have higher fuel needs than estimated by BREDEM.

[11] EST, Home Energy Pay As You Save Pilot Review, DECC 2011
http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/microgeneration/2670-home-energy-pay-as-you-save-pilot-review.pdf
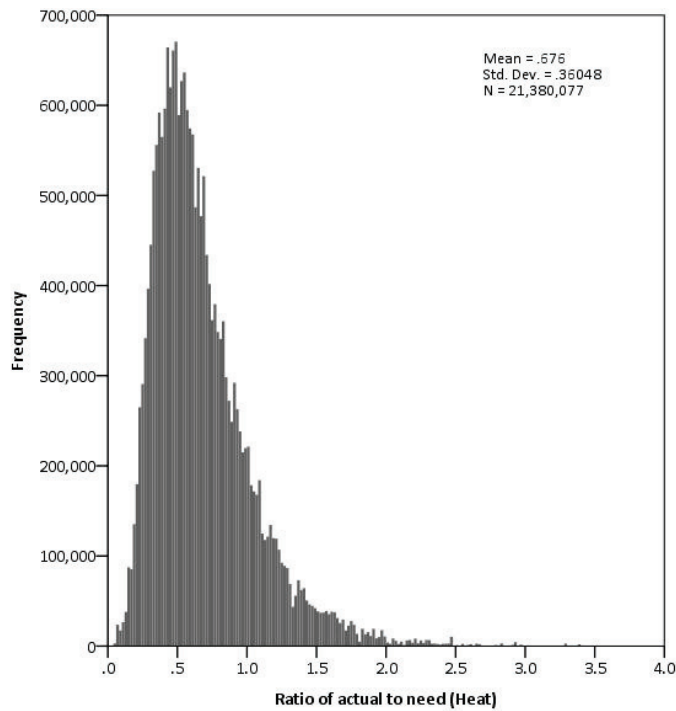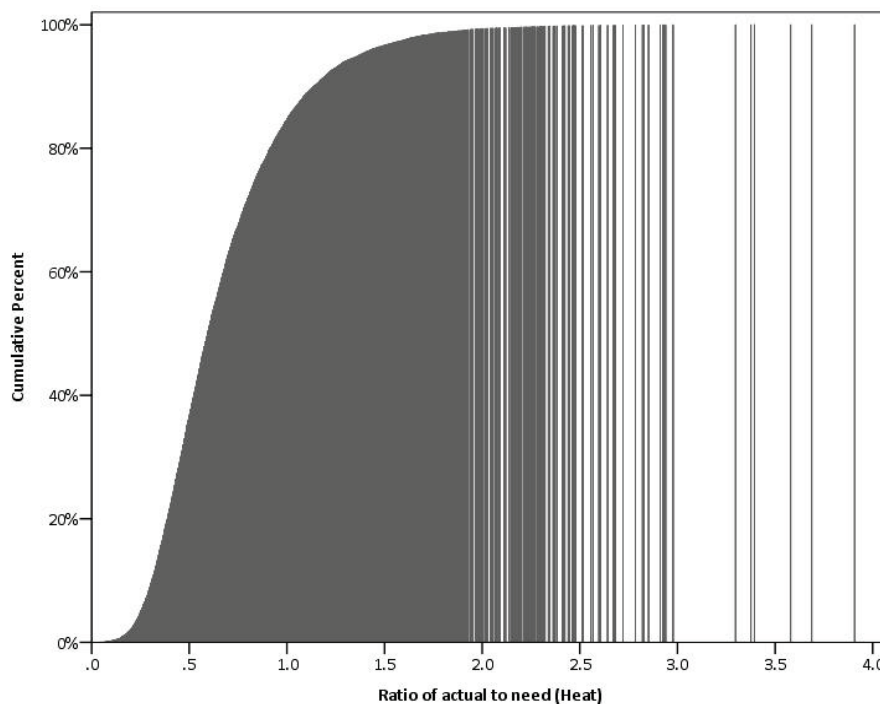
Figure 7: Cumulative percent frequency histogram of consumption ratio

Given that the majority of households in the dataset 'under-consume', it is the extent of under-consumption that is interesting. We want to identify the more extreme levels of 'under-consumption' and seek to understand what is driving this. This is of particular interest because it is implausible to argue that falling below 100% of energy need gives cause for concern, as this would suggest that most UK households keep their homes at temperatures that create problems. When viewing the analysis that follows, recall that the *lower* the consumption ratio, the greater the household is considered to be *under-consuming*.

Figure 8: Mean consumption ratio by (1) AHC and (2) AHC equivalised income decile
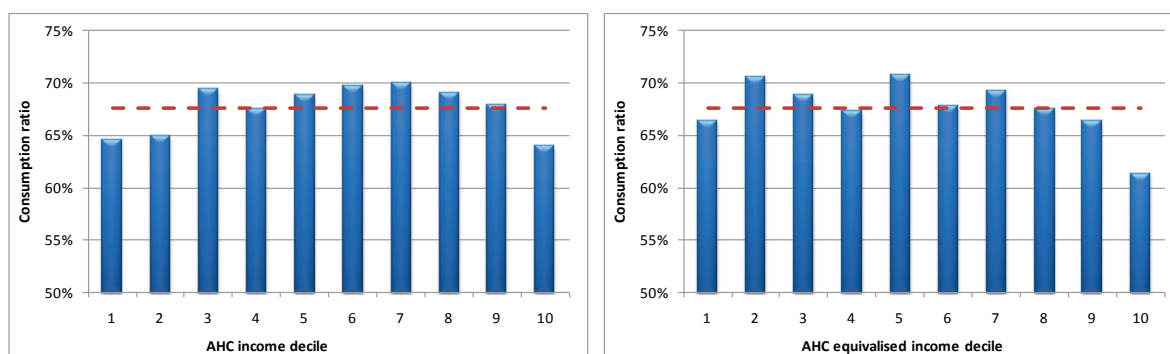

Figure 8[12] shows the mean consumption ratio by income deciles[13] (Annex II contains additional charts of consumption ratio by key socio-demographic variables). The dashed line shows the mean across the dataset as a whole. There appears little discernable difference in the mean consumption ratio by income deciles, with the poorest and wealthiest income brackets having the lowest average consumption ratio (i.e. appearing to under-consumer the most).

Dividing the consumption ratio into deciles (such that decile ten represents the greatest level of under-consumption) and cross-tabulating this with income deciles shows a similarly dispersed pattern (see Figure 9 below). A regression model of income against consumption ratio confirms this lack of linear relationship with an R^2= 0.00 (AHC) and 0.002 (AHC equivalised).

Figure 9: Consumption ratio deciles by (1) AHC and (2) AHC equivalised income decile[14]
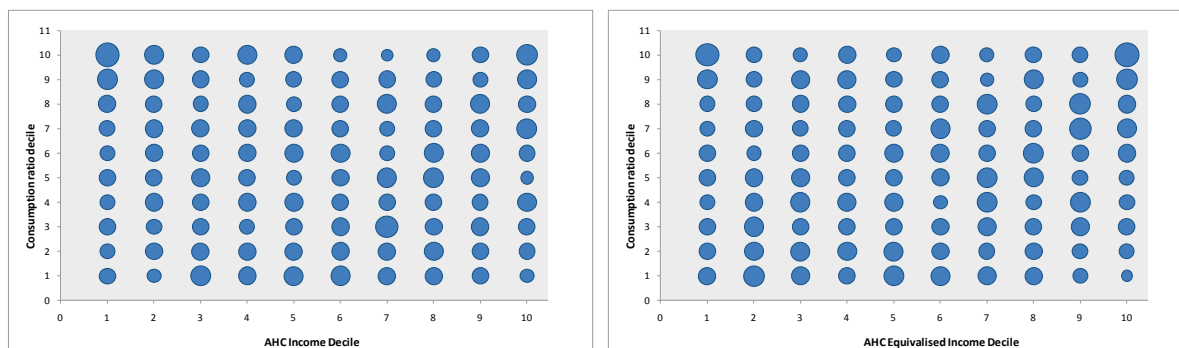

The analysis of the under-consumption ratio by socio-demographic variables demonstrated some discernable differences for household composition and tenure (see Annex II for charts). Figure 10 shows that under-consumption is greatest among single people, both pensioners and non-pensioners. Section 4.2.3 below uses advanced statistical techniques to explore these breakdowns in greater depth e.g. multiple linear regression and CHAID (Chi-squared automatic interaction detector).

Figure 10: Mean consumption ratio by household composition

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[12] Note the y-axis has been re-scaled.
[13] Here and in the later modelling, we use "equivalised" income deciles showing where households lie in the income distribution after adjusting for family composition. These adjustments allow us to consider which households have the highest and lowest incomes relative to their overall spending needs – so a large family will be regarded as having fewer resources available, relative to need, than a small family with the same income.
[14] The width of bubble represents number of households.
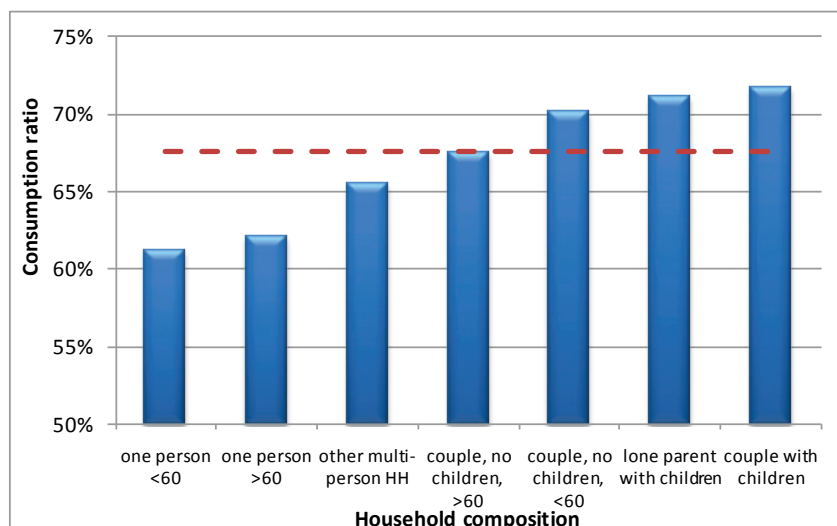
3.2.2. Setting a lower threshold of under-consumption

The underlying causes for under-consumption are likely to be important considerations for the design of future policy. Figure 8 shows a higher extent of under-consumption at the extremes of the income scale. However, policy should be more concerned about the drivers of under-consumption at the lower end of the income scale.

What level of under-consumption of fuel should interest us? One potential answer, in the analysis of fuel poverty, may be the level at which more marked relationships between low income and under-consumption become apparent. Deprivation surveys such as the Poverty and Social Exclusion Survey take such an approach to setting a poverty line based on people who lack a certain number of socially defined necessities. The threshold, in terms of number of necessities lacked, is selected according to the number of necessities above which deprivation becomes more strongly associated with income.

The team therefore examined the distribution of under-consumption by income deciles on different thresholds of under-consumption. For example, the team created a new categorical variable where the under-consumption ratio was less than 60%; the proportions of households within each decile that fell into this category were then explored. Figures 11 and 12 show the proportion of households by decile that fall within the under-consumption ratios of less than 60% and 40% respectively.

Figure 11: 60% threshold (all households with CR<60% defined as 'under-consuming')
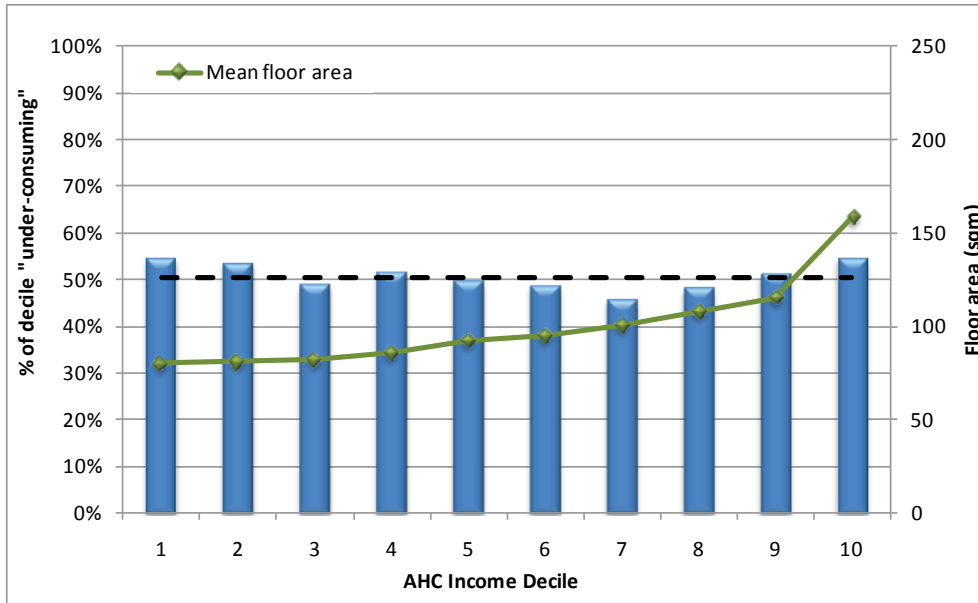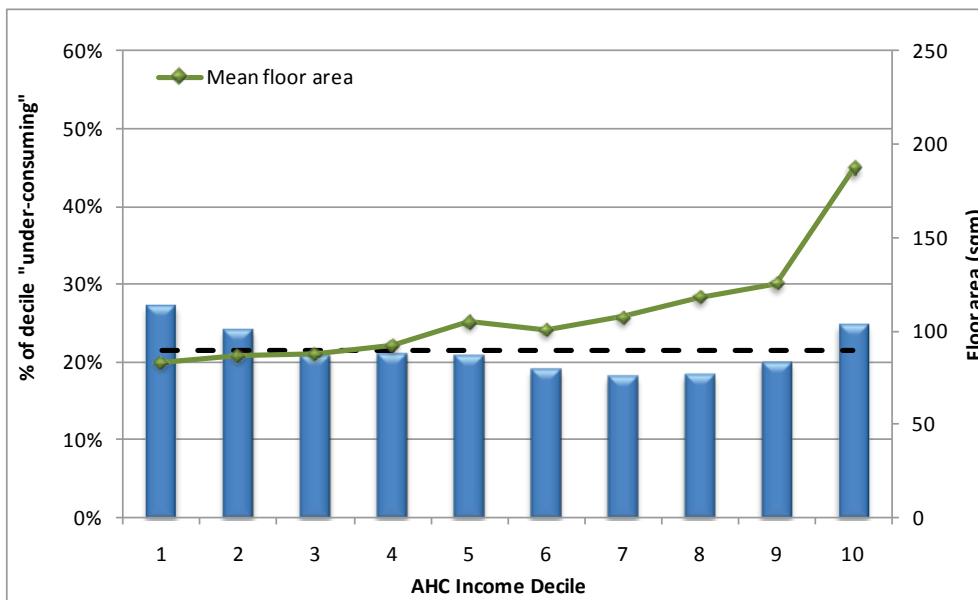
Figure 12: 40% threshold (all households with CR<40% defined as 'under-consuming')

Both charts show a higher proportion of under-consuming households at the extremes of the income distribution. The relationship is more marked among those consuming less than 40% of "need", which is much less common (affecting 21% of households) than consuming below 60%

(affecting half the population). This relationship pertains but does not become markedly stronger if we lower the threshold further. It would appear reasonable to assume that:

- In lower income households, under-consumption is driven by a combination of household characteristics, building characteristics and income.
- In higher income households, under-consumption is driven by a combination of household characteristics and building characteristics.

The average floor area of under-consumers by income decile shown on Figures 11 and 12 above suggest that it is the presence of large homes that drives under-consumption among better off households. Multiple linear regression analysis could be used to further explore the relationship and key driving factors of under-consumption. Whilst this is beyond the scope of this research, the team has explored one regression model, with the consumption ratio ('actual heat kWh' as a proportion of 'need heat kWh') as the dependent variable and a range of independent 'dummy' variables derived from socio-demographic data.

The results suggest that physical household properties - for example, number of bedrooms, dwelling type and heating fuel – and occupancy characteristics –for example, number of children and household composition – are more important predictors of under-consumption than income (albeit with the latter still significant). There is much scope to build on and further this analysis to explore in more detail the factors driving under-consumption in low income households compared to better off households. Due to time constraints this is not possible within this research; however, we were able to apply a 'tree' classification analysis to generate some further insights, as described in the following section.

3.2.3. Key factors related to under-consumption

The team used an advanced statistical technique (Chi-squared Automatic Interaction Detector (CHAID)) to identify key characteristics of households who under-consume. CHAID creates clusters or "nodes" of households that have similar defining characteristics in relation to the dependent variable (i.e. the ratio of actual heat consumption to need). Full details of the CHAID analysis are shown in Annex IV. The key characteristics of clusters identified as being the most significant under-consumers are described below:

Low income, single adults, in small, rural, off-gas terraced houses and converted-flats (n=436,500; Consumption ratio = 0.41)

The group identified as under-consuming the most is dominated by low income households (61% in AHC deciles 1-3) living in small homes (one, 23%, or two, 40%, bedrooms), mid-terrace (29%) and converted flats (17%) in non-urban areas (22% in villages). All are occupied by a single adult only (57% being pensioners), most of whom who own their property outright (40%) or privately rent (21%). None have gas central heating, but instead rely on electricity (80%) or solid fuel (18%). This suggests under-consumption in these households is driven by a combination of (low) income and physical structure (property type and heating fuel suggests the modelled level of heat 'need' is relatively high).

Middle-income couples in rural off-gas terraced houses (n=312,835; Consumption ratio=0.46)

The next highest under-consuming group consists entirely of couples, (some - 18% of the group – with two children), living mainly in small to medium-sized homes (35% 2-bed, 46% 3-bed), electrical (72%) or solid fuel (21%) heated terraced houses in non-urban areas, largely in the south west and south east of England. Most have an HRP[15] in full time employment, aged between 45 and 65 (54%), and over half (57%) are in AHC income deciles 4-7. There is a mix of tenures although again over one-fifth privately rent (almost double the population average).

Low-income, single, under-occupying pensioners (n total=855,286; Consumption ration = 0.46 to 0.51)

This combines two groups with very similar characteristics in terms of housing characteristics: both nodes consist entirely of single adult households, occupying medium-sized (84% 3-bed), gas centrally heated semi-detached houses (45%) in urban areas. One cluster is notably lower income (47% in deciles 1-3) and consists predominantly of pensioners who own their home outright (75%). This represents a typically fuel poor group of under-occupying older people. Under-occupancy is likely to be a key factor behind their under-consumption. However, their heating needs may well be high, given their older age, and their under-consumption may also be poverty driven.

Low-income single adults, in small, mains gas heated, rented converted flats/terraced houses (n=463,584; Consumption Ratio = 0.51)

This cluster again consists entirely of single adults, all living in converted flats (48%) or end-terraced (52%) houses in urban areas (a quarter in London) with mains gas heating. Properties are small (1 or 2 bedrooms) and a high proportion are private rented (24%) or renting from RSL (17%). There is a mix of age ranges, although 40% are retired. This is a low income group with 47% in deciles 1-2 and 64% in deciles 1-3. Given their occupancy of small properties, this group's heat needs are likely to be relatively low. Income could therefore be an important factor driving under-consumption among these households.

Rural off-gas properties (n=441,460; Consumption ratio = 0.53)

The key defining characteristic of this node is its rural off-gas status, with 75% and 24% of households having electric and solid fuel heating respectively. There are no single person households. However, apart from these notable characteristics, the socio-demographic make-up of this group is not dissimilar to the 'average' for the population as whole. There is a range of income groups although there is a slight tendency towards lower income bands, reflected by the employment mix with 39% retired. There are no single person households; occupancy is mixed, with 38% being pensioner couples and 41% being households with children (including 16% being lone parent). There is a mix of property types; properties are medium-sized (54% 3-bed); and a mix of tenures, although private renting is slightly higher than average (17% compared to 12% average). The heating fuel and rurality of households in this group therefore appears to be the key driver of under-consumption.

High-income multi-unit households and families in large London houses (n=573,339; Consumption ratio = 0.54)

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[15] HRP refers to the household reference person.

This group is notably high income (25% are in decile 10; 55% in deciles 8-10). There are no single adults, but a high proportion of "multi-unit" households, i.e. those including more than one adult other than partners (32% with 3+ adults, 12% of whom also have children in the house). They live in mains gas heated, urban (all in London), larger than average (41% have 4 or more rooms) semi-detached (53%) and end-terraced (20%) houses. The HRP is mainly middle-aged (45% are age 45-55) and properties are owner occupied (43% with mortgage). The make-up of this group suggests affluent families with adult off-spring still living at home. Their under-consumption is likely to be driven by a high estimated fuel requirement of the property and/or a lower than assumed occupancy (since occupants are mainly employed they are therefore more likely to be out of the house for longer periods of the day).

Low-income, under-occupying single adults with mains gas heating (n=349,232; Consumption ratio = 0.54)

All households in this node are single adults without children, 60% being pensioners. They are low income (23% are in decile 1; 54% in deciles 1-3), although a high proportion own their home outright (52%). They occupy medium-sized properties (82% being (and none fewer than) 3-bed), with mains gas heating in urban areas. This suggests another typically fuel poor group of low-income under-occupying single adults. Their under-consumption is likely to be the result of a high estimated fuel requirement for the size of the property relative to the low occupancy status.

3.3. High fuel expenditure relative to income ('low income, high expenditure')

While fuel poverty may lead to under-consumption of fuel causing thermal discomfort and health risks, another possibility is that it causes high levels of consumption relative to what a household can afford. The team measured high energy use relative to income, in this case expressed in terms of actual energy expenditure rather than energy consumption, since it is the spending pressure that is of most interest here i.e. in terms of £s spent rather than kWhs used. This is a function of both consumption and fuel cost. A "relative fuel spending" variable can thus be defined as the ratio of fuel spending to income, and a "high relative spender" category of household defined as those for whom this ratio exceeds 10% (see table 5 below and discussion that follows).

$$\text{Relative fuel spending}[16] = \frac{\text{Actual Energy Bill (£)}}{\text{AHC Income (£)}}$$

Comparing thresholds

Note that, as with other comparisons to income in this paper, the threshold of relative spending on fuel is based on an after housing cost definition of income. This is used to give an idea of how fuel

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[16] The original 10% definition of fuel poverty was based on households in the lowest incomes (30%) that spent twice the median on fuel costs. The proportion relative to income of 10% was based on 1988 data from the Family Expenditure Survey, now known as the LCF (see Boardman B., Fuel Poverty: From Cold Homes to Affordable Warmth, 1991, table 3.4).

spending impacts on net disposable income after non-discretionary outgoings, e.g. rent and mortgage payments. However, the threshold of 10% used to calculate fuel poverty based on need uses 'before housing costs' income, and is therefore a higher threshold (see table 3 below for example). This means that a household on the threshold of fuel poverty that spends exactly what they "need" to in order to meet temperature requirements would actually be spending more than 10% of their AHC income. (For example, in the table above, the 10% of median BHC income equates to 12% of AHC income).

However, as noted earlier, the actual *norm* is to spend considerably less than "need" on fuel. Since the 10% fuel poverty threshold is derived from an actual norm – it originally represented twice the median percentage of income spent on household fuels – it is relevant to compare current norms of the percentage of income that households need to spend on fuel and the percentage they actually do spend.

Analysis of the EHCS dataset used in this study shows that the median fuel requirement ('need') equates to 6% of BHC income and the median level of actual spending on fuel also equates to 6% of AHC income (table 4). In other words, a given percentage of BHC income that <u>needs to be spent</u> on fuel has a similar relationship to the norm as the same percentage of AHC income that is <u>actually spent</u> on fuel. For this reason, 10% thresholds in both cases have similar meanings in relation to the norm.

Table 3: Illustrative measures of income and the 'fuel poverty' threshold

	Median	10% threshold
BHC income	£21,835	**£2,184**
AHC income	£18,348	**£1,835**

Table 4: Median values of the measures of fuel spend as % of income

	Median
Relative fuel spending (actual / AHC income)	5.6%
Fuel Poverty (need / BHC income)	6.3%

Table 5: Descriptive statistics for high relative spenders (overall, whole dataset)

	Count (HHs)	N %	Mean	Median	Minimum	Maximum
"High relative spenders" Actual energy cost >= 10% AHC income	4,090,662	19.1%	0.186	0.129	0.100	31.436
Actual energy cost < 10% AHC income	17,289,415	80.9%	0.051	0.048	0.003	0.100

Table 5 shows that 19% of English households could be defined as high relative spenders. This is slightly lower that the current estimated number of fuel poor households (23.5% or 5.1 million in 2011[17]). These households on average have a relative fuel spending of 18.6% of income compared to 5.1% for the remainder of the population.

Figure 13: Proportion of income decile with high relative spending on fuel
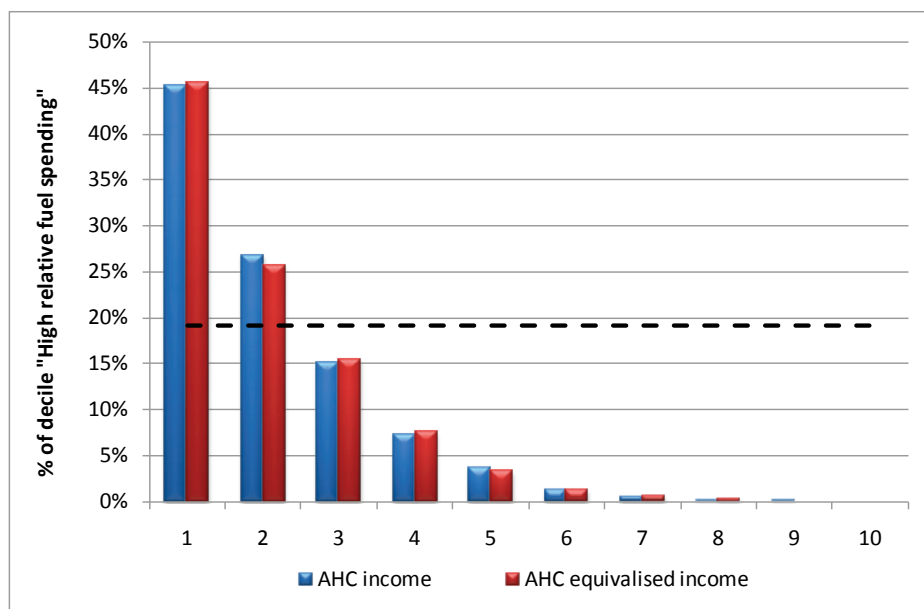

Table 6: Relative fuel spending by high and not-high categories (AHC Income only)

AHC Income Decile	Not high relative fuel spending		High relative fuel spending	
	Count	Column %	Count	Column %
1	290,456	2%	1,847,504	45%
2	1,039,678	6%	1,098,228	27%
3	1,520,854	9%	616,900	15%
4	1,840,009	11%	297,482	7%
5	1,989,698	12%	148,511	4%
6	2,082,858	12%	55,256	1%
7	2,115,406	12%	23,698	1%
8	2,136,035	12%	1,591	0%
9	2,135,723	12%	1,492	0%
10	2,138,698	12%	0	0%

Unlike the under-consumption ratio, the distribution of high relative fuel spending amongst deciles is heavily concentrated at the lower end of the income scale; see Figure 13 and Table 6 above. The bottom two income deciles contain 45% and 27% of high relative spenders respectively with the majority of households in these deciles spending more than 10% of their AHC income on fuel. In contrast, the top three income deciles contain only an estimated 3,000 households in this category – and this is based on too few households in the survey to be statistically significant.

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[17] CSE, Improvement Prophet, August 2011

Figure 14 below shows the mean relative fuel spend, by income decile, for high relative spenders and non-high spenders. High relative spend is most extreme in the lowest income deciles with a very high relative fuel spend for the lowest decile and a relatively consistent mean for income deciles 2 to 7 (relative fuel spend falls from 13.5% of income to 11%; the sample size is too small for deciles 8 and 9).

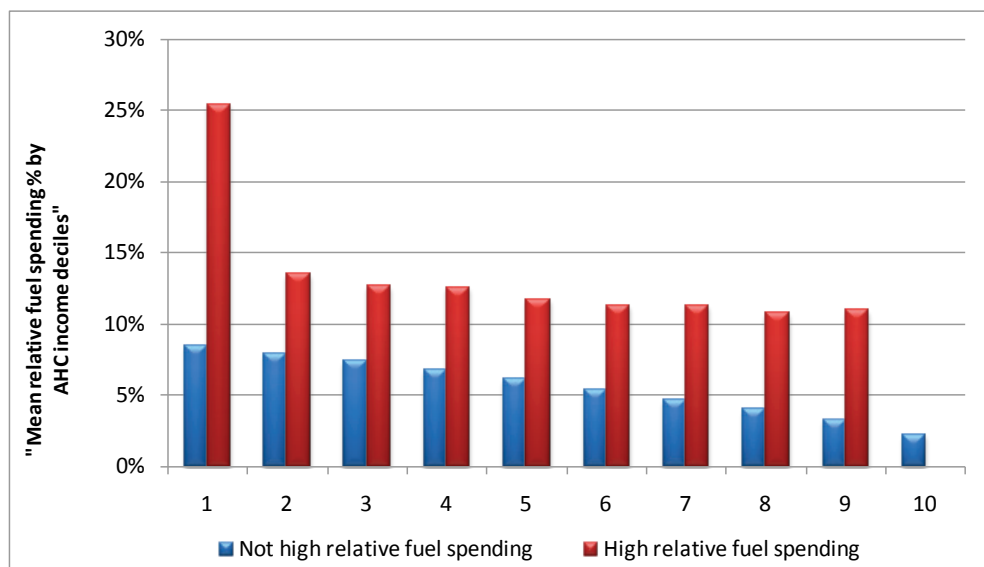**Figure 14: Mean relative fuel spending split by high and non-high spenders**

Figure 15: Proportional distribution of high relative fuel spenders, fuel poverty and under-consumption by income deciles (where the threshold for under-consumption is 60%)
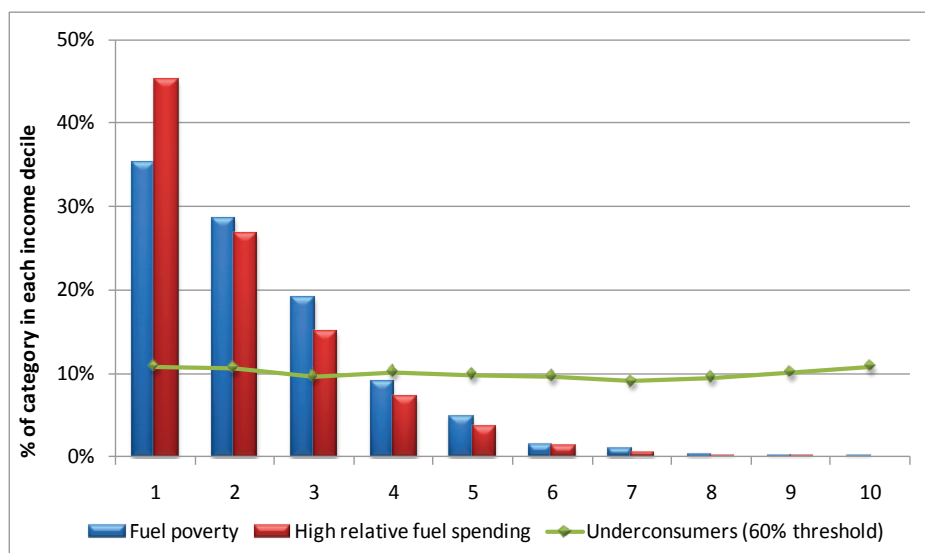

Figure 15 shows the distribution of high relative fuel spend, fuel poverty (based on the 2007 EHCS) and under-consumption (whereby households with a consumption ratio below 0.6 (the dataset median) are defined as under-consumers) by (AHC) income decile. The distribution of high relative fuel spend displays a similar pattern to fuel poverty with a substantial concentration among the bottom three income deciles, whereas the trend for the distribution of under-consumers is relatively even- between 9% and 11% for each decile.
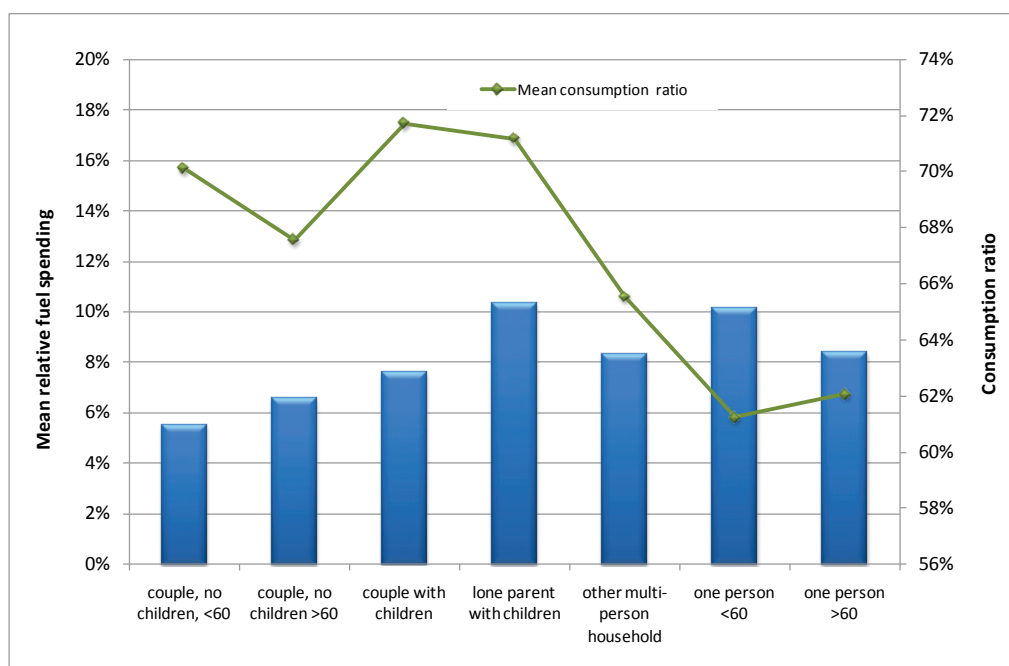
Figure 16: Mean relative fuel spend and under-consumption by household composition

Figure 16 shows which groups have on average the highest fuel spend relative to income, and for comparison, a reminder of which groups have consumption that is highest and lowest relative to need. Lone parents are the most likely to have high fuel spend relative to income, and also consume at high levels relative to need, corresponding with a relatively low chance of under-consumption. This suggests that this group, whose income profile is low, prioritises meeting fuel bills, thus putting pressure on other parts of their budget. Couples with children, who are also less likely than average to under-consume, are able to do so with less pressure on their budgets than lone parents, since their average income profile is higher. On the other hand single people under 60 have a high chance both of under-consumption and high consumption relative to income.

Annex V contains further plots of mean relative fuel spend for key socio-demographic variables.

3.4.   The relationship between fuel poverty, fuel spend and low income

This paper has sought to understand the distributions and drivers for both 'under-consumption' and 'high relative spend'. This section explores the distribution of these groups in relation to whether they are below a threshold of low income, as well as whether they are in fuel poverty. This allows us to see the extent to which these problems occur among households who have inadequate overall resources.

The analysis looks at:

A. Households identified as under-consuming relative to their need, using a threshold of 40% for under-consumption since this correlates with the node mean for the most significant low-consuming cluster identified in the CHAID analysis (see section 2.3).
B. Households with high fuel expenditure – defined as those with an actual spend that is greater than 10% of their AHC income.

Relative to:

1. The formal definition of income poverty, 60% of median equivalised income;
2. The MIS threshold for income adequacy, their MIS required income is less than their AHC income;
3. The full income definition of fuel poverty i.e. the standard definition most known to policy makers whereby income includes housing benefit, income support for mortgage interest relief and council tax benefit[18].

The total count of households in each individual category is shown below for reference.

Table 7: Count and proportion of households in each category

	Count	% of population
A. Under-consumers (40%) threshold	4,575,616	21%
B. High relative fuel spend	3,872,386	18%
1. Income poor	4,257,850	20%
2. MIS threshold	7,371,631	34%
3. Fuel poor (2007 EHCS)	2,818,701	13%

The reason for looking at two different thresholds of low income is to explore the association of fuel spending difficulties with:

1. people likely to be living in hardship (below the poverty line); and
2. a wider group of people who may not be in poverty but whose incomes do not come up to an "adequacy" threshold defined by members of public as the minimum needed to have the choices and opportunities required to participate in society. The adequacy line is for most households somewhat above the poverty line: usually around 70% of AHC income for working age families, although closer to the 60% threshold for pensioners.

Figure 17: Household counts for under-consumers (<40% need), income poverty and fuel poverty

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[18] NB This is not the same as the EHCS AHC income definition which takes into account all of the components of the BHC measure but then removes certain costs related to maintaining and occupying a dwelling.

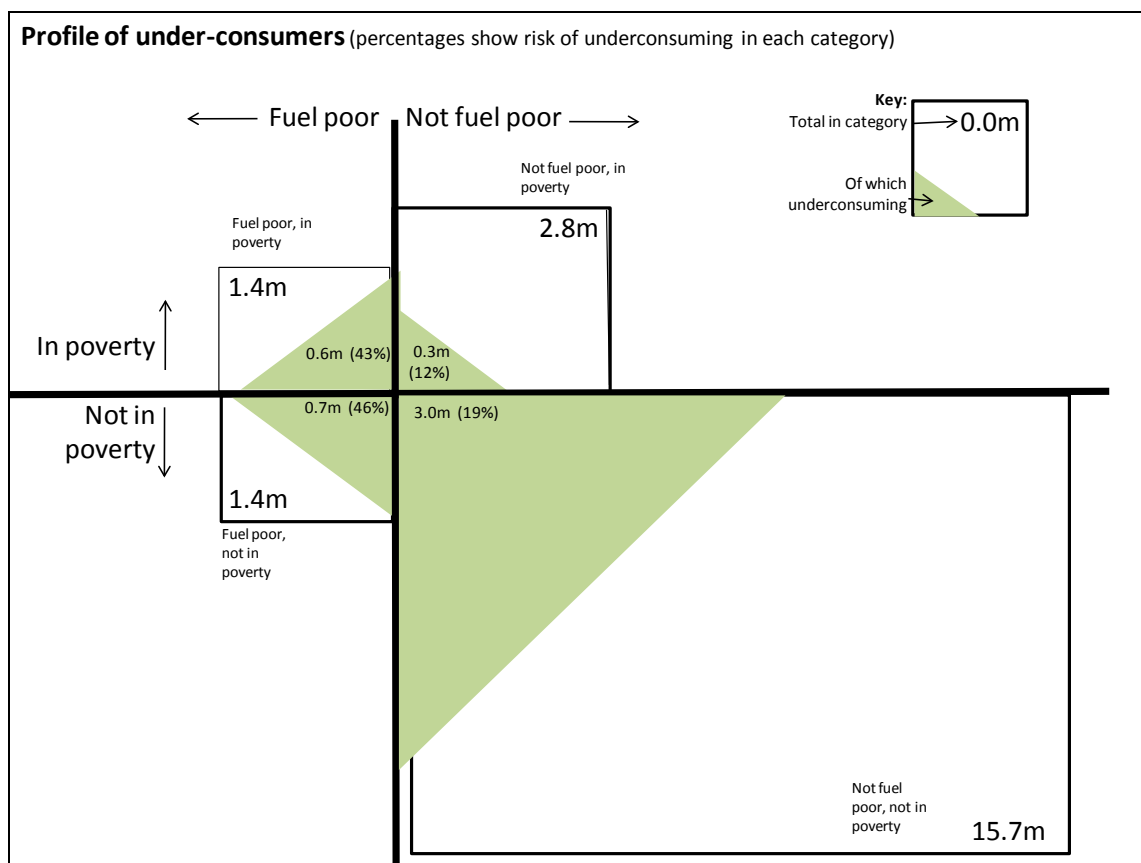**Profile of under-consumers** (percentages show risk of underconsuming in each category)

Figure 17 looks at under-consumption according to whether households are below the poverty line and in fuel poverty. It shows that the risk of under-consumption is much higher for fuel poor households, but within this group, being in income poverty does not affect the risk. This suggests that among people with a high fuel requirement relative to income, those for whom fuel poverty is driven by overall poverty are no more likely to under heat their homes than those who have somewhat higher incomes but particularly high fuel costs. This is a significant finding, as it suggests that people are unwilling to pay a very high proportion of their income on fuel even if in theory they can afford to.

Another important finding of Figure 17 is that most under-consumers, even on a 40% threshold, are neither fuel poor nor in poverty, so any measure to tackle fuel poverty could only reduce the level of under-consumption to a limited degree. On the other hand, given that the *risk* of under-consumption is greater for those who are fuel poor, we may regard it as more likely that an under-consumer in fuel poverty is facing enforced hardship than one who is not in fuel poverty, for whom under-consumption may be a result of choice and lifestyle. Hence, the large number of households in the bottom right triangle of Figure 17 may be of less concern than the smaller numbers in the triangles on the left.

Figure 18 shows that high relative fuel-spend has a very different incidence in this respect than under-spending on fuel. People who are in poverty and who have to spend at least 10% of their income on fuel have a very high chance - 85% - of actually spending exceeding 10% of AHC income for this purpose. On the other hand, people not in poverty are less likely to have high relative fuel spend, even if their relative need is high. This can be explained by the fact that many people with low incomes have particularly high relative fuel spending requirements, so even if they under-spend

it can put a strain on their resources. Even people without a very high fuel spending requirement have a high chance of spending more than 10% of their AHC income on fuel if they are in poverty. (Note that the threshold for fuel poverty is in this case higher than the threshold for high relative fuel spend, since the former is based on 10% BHC income and the latter on 10% AHC.)

Comparing Figures 17 and 18, it is clear that among people in fuel poverty, being in income poverty is associated with an increased chance of having high fuel spending relative to income, but not in an increased chance of under-consuming fuel. Hence, fuel poverty appears to put extra pressure on the overall household budgets of low income households, but does not obviously make low income households more likely to under-consume fuel than those not on low incomes.

Figure 18: Household counts for high relative fuel spend, income poverty and fuel poverty
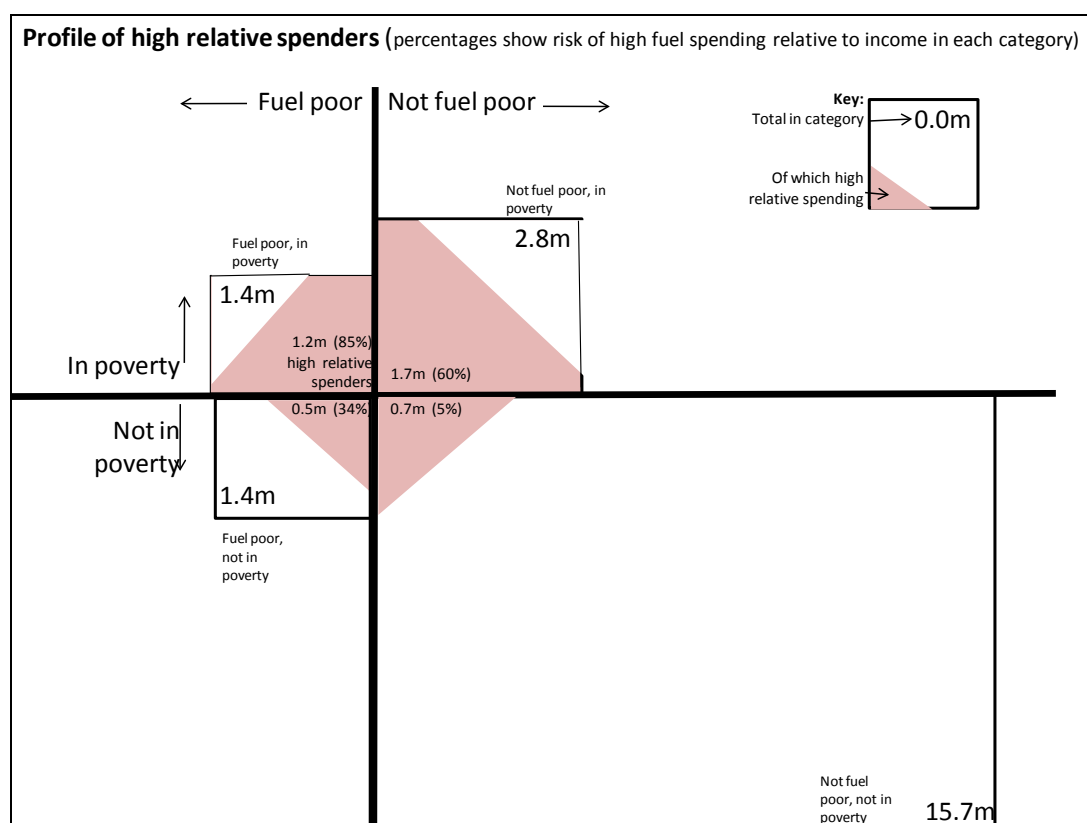
The same analysis can be made using the Minimum Income Standard threshold of low income, to see the extent to which people affected by under-consumption and high relative fuel spend are on adequate incomes, rather than just non-poverty incomes. (The poverty line, based on low income relative to the median, is for most households somewhat lower than the "adequacy" line set by the Minimum Income Standard for the United Kingdom.[19] The latter represents a threshold below which households cannot generally reach a living standard considered to be "acceptable" by members of the public questioned in research. People below this standard can be expected to struggle to achieve an acceptable standard of living, even though they may not necessarily be in hardship.) These results are shown in Figures 19 and 20.

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[19] See www.minimumincomestandard.org

The general pattern of these graphs are the same as for income poverty, but with a larger number of cases of both under-consumption and high relative fuel spend where households are below the low income threshold. In the case of under-consumption, there is a jump in the number of households who are not fuel poor but have low incomes and who spend much less than they need to on fuel. However, the majority of under-consumers do have adequate incomes. On the other hand, over four in five households spending a high proportion of their income on fuel do not have adequate incomes. Over two million of these households are not counted as being in fuel poverty, yet fuel puts a heavy burden on incomes, leaving families short of what they need for a socially acceptable standard of living.

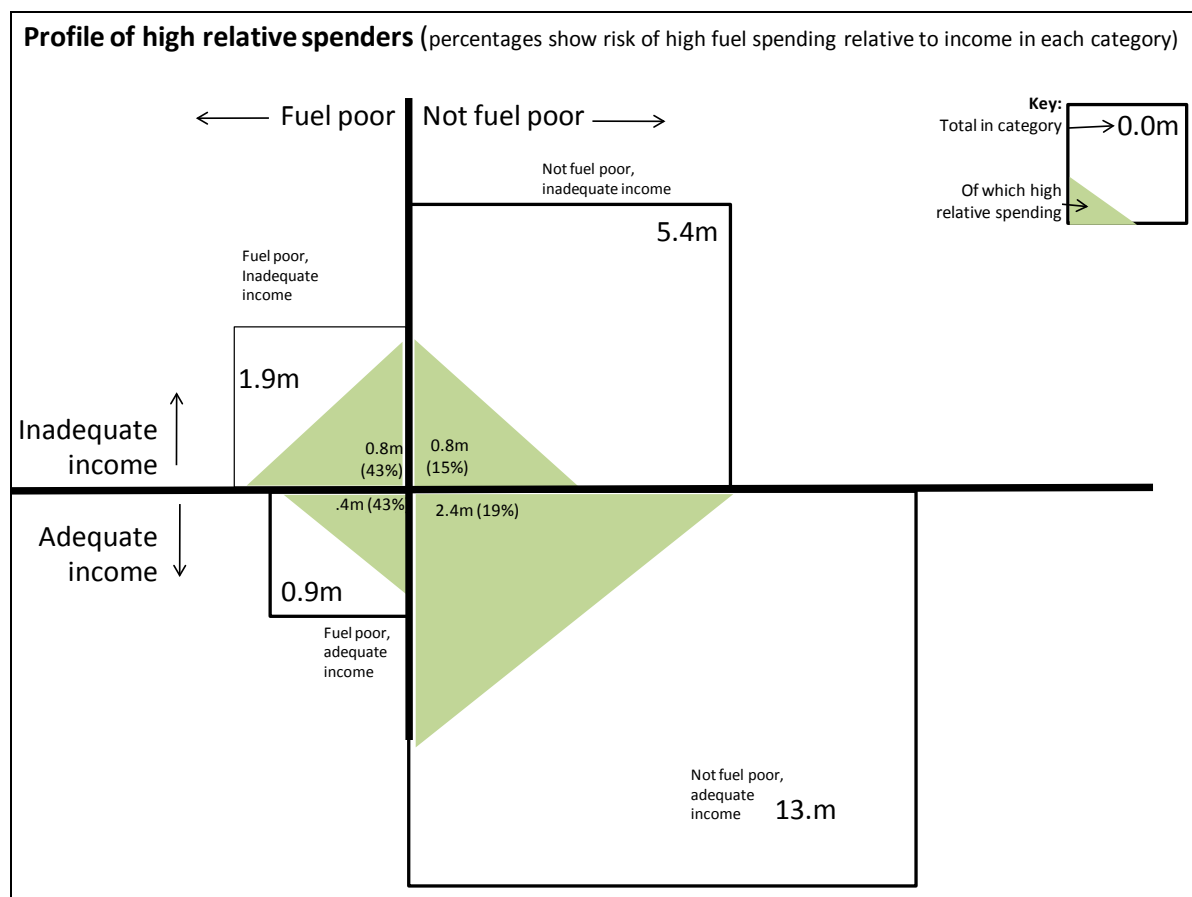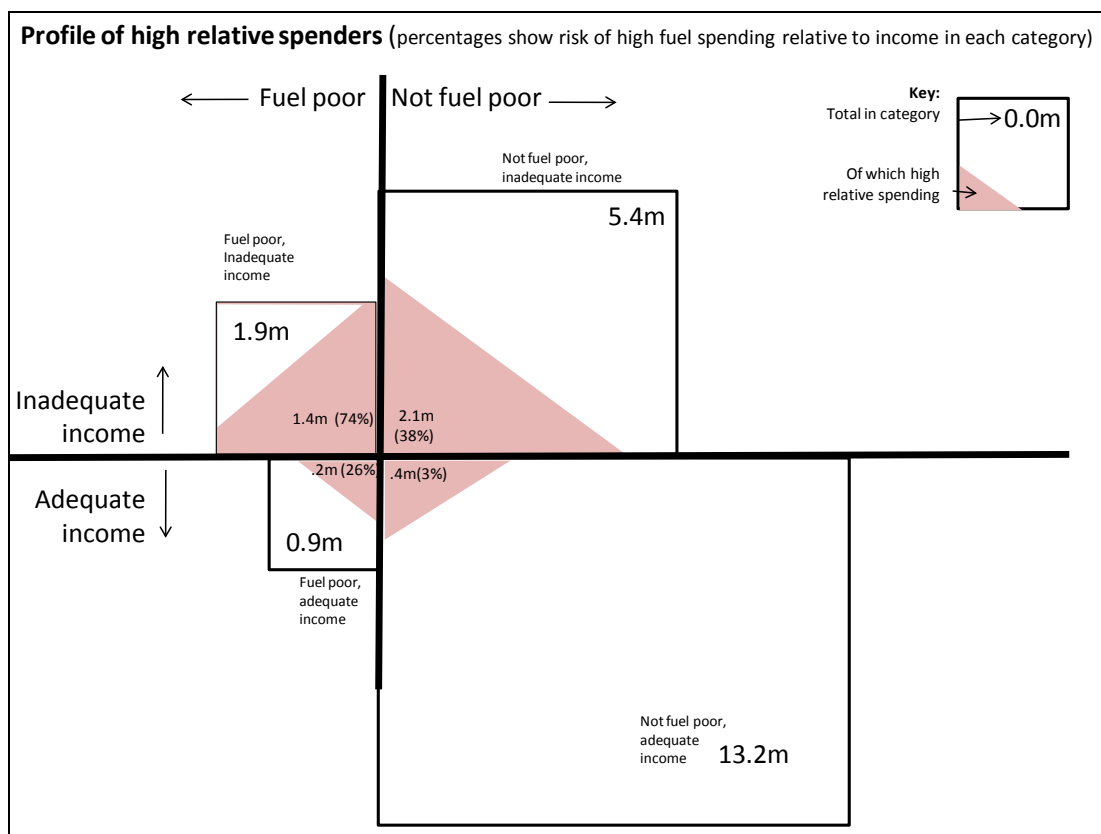**Figure 19: Household counts for under-consumers (<40% need), income adequacy and fuel poverty**

Profile of high relative spenders (percentages show risk of high fuel spending relative to income in each category)

Fuel poor ← | → Not fuel poor

Not fuel poor, inadequate income
5.4m

Key:
Total in category → 0.0m
Of which high relative spending

Fuel poor, Inadequate income
1.9m

0.8m (43%) | 0.8m (15%)

Inadequate income ↑

.4m (43%) | 2.4m (19%)

Adequate income ↓

0.9m

Fuel poor, adequate income

Not fuel poor, adequate income 13.m

Figure 20: Household counts for high relative fuel spending, income adequacy and fuel poverty

Profile of high relative spenders (percentages show risk of high fuel spending relative to income in each category)

4 Fuel consumption, fuel spending and future approaches to measurement

4.1. Developing better measures

The evidence presented in this paper about fuel consumption and fuel spending is not intended to suggest an alternative measure of fuel poverty but to put the existing measure in context. Whatever approaches are developed as a result of the Hills Review, better knowledge of the actual outcomes of high fuel costs in terms of fuel spending can aid understanding of the impact of fuel poverty. Our findings show that such impact differs markedly from one group to another, both in terms of household composition and whether the households are below an income threshold.

Up until now, the relationship between heating requirements and fuel spending has not been monitored. The only source of information on household energy requirements has come from the detailed housing surveys: the English House Conditions Survey (EHCS), it successor the English Housing Survey and their equivalents in other parts of the UK. Energy consumption is not measured in household surveys. The Living Costs and Food (LCF) Survey collects data of fuel expenditure which can then be used to derive consumption; however, the survey has limited data on physical household characteristics, for example building fabric.

In the past year, three new approaches to observing relationships between fuel requirements, fuel usage and income have emerged. One, used in this paper, involves the matching of surveys, to impute information from the spending survey (LCFS) on actual fuel spending levels to the EHCS.

Using this approach the Centre for Sustainable Energy[20] has succeeded in developing models that produce results with a high degree of plausibility.

A second, more direct approach involves using actual supplier data in new ways. A first report on DECC's National Energy Efficiency Data framework (NEED) has shown how data on energy use for the whole population provided by suppliers can be combined with other information about households to estimate the relationship between fuel use and other variables, such as the introduction of energy-saving measures and income[21]. However, the estimates of income and home energy efficiency used in this model are at present very crude: the big advance may be to match the data on individual homes to the same homes in the Housing Surveys.

Finally, a third approach is the study of fuel consumption based on the follow-up survey of a sample of the English Housing Survey (taking place in 2011-12). This can provide supplementary information but is limited in that the follow-up surveys only take place very occasionally.

We think that there is considerable potential for using these approaches together in order to develop improved indicators of fuel consumption that can be related to the condition of people's homes and their incomes. Even if relatively accurate population data on consumption can be regularly matched to cases in the English Housing Survey, the modelling techniques used for this paper will continue to be relevant. Serious imperfections in the income measure in the EHS, the degree of estimation required in any measure of fuel consumption and the limitations of analysis relating to the sample size make the techniques we have used for estimating patterns of outcomes of continuing relevance.

4.2.   How warm is necessary?

A key feature of our results is their demonstration that, on the present definition of fuel requirements, almost everyone "under-consumes" energy in the home, regardless of income levels. We have therefore used a narrower definition of under-consumption than that implied by the EHCS/EHS definitions. This reflects the fact that the current standard heating regime used in the calculation of fuel poverty does not reflect the level to which most people heat and / or occupy their homes. This is a major weakness in the current way in which fuel poverty is measured.

The World Health Organisation (WHO) recommends a temperature threshold of 18°C, with an increase of between 2 and 3°C for those vulnerable to the effects of cold strain (i.e. the elderly, the young etc)[22]. The fuel poverty methodology used the WHO recommendations as a basis for the definition itself. However, other studies have used revised thresholds for thermal comfort to allow for the range of recommended WHO values and differences in householder ages. For example, Healy[23] used the WHO's lower bound benchmark of 18°C for thermal comfort for those aged under 65 with the benchmark of 20°C or more for those aged 65 or older.

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[20] Working with the Universities of Bristol and Oxford and with funding from the Joseph Rowntree Foundation.
[21] DECC, 2011. National Energy Efficiency Data Framework – Report on the development of the data framework and initial analysis. http://www.decc.gov.uk/assets/decc/11/stats/energy/energy-efficiency/2078-need-data-framework-report.pdf
[22] WHO (1987), Health Impact of Low Indoor Temperature, Copenhagen, WHO Regional Office for Europe
[23] Healy, J. (2004), Fuel Poverty and Health: A Pan European Analysis, Ashgate Publishing Ltd

The EHS follow up survey in 2011/12 will provide more information about the current relationship between actual levels of thermal comfort, income and the state of people's homes. The follow up survey will place temperature monitors in a sample of homes, to produce detailed data on the warmth of different parts of the homes at different times of the day and night. Results from this survey could potentially be used to develop more representative thresholds of required thermal efficiency. For example, do we heat to higher temperatures for shorter periods or lower temperatures for comparable times?

One future possibility[24] is to consider how actual temperatures relate to people's perceptions of thermal comfort. The EHS follow up survey will ask respondents if they feel that they are able to heat their homes to adequate temperatures. A straight forward exercise would be to look at the temperature level associated with an increased risk of answering 'no' to this question. If this were at a very low level at which clear risks to human health are evident, we might conclude that people are being unrealistic or misinformed about desirable temperatures. On the other hand, if the figure is lower than the 21°C living room temperature presently specified, but not as low as a level at which studies have found negative health effects, this could help inform which standard to apply. Such an approach would reflect the fact that thermal comfort is not just an aspect of health standards, susceptible to medical evidence, but also a feature of living standards, whose acceptability is influenced by social norms.

4.3. Future targeting of resources

The delivery of the UK Government's Strategy to eradicate fuel poverty has typically used targeting proxies that are based on means tested benefits. For example, the Carbon Emissions Reductions Target (CERT) now targets the Priority Group (PG) and the Super Priority Group (SPG). Since 2008 the CERT PG has included older householders (those over 70) to increase the number of eligible households and also reflect the need for higher thermal comfort within this group. The use of benefits and age as proxy measures has the advantage of administrative simplicity with respect to delivering programmes. However, research has shown that households on means tested benefits or tax credits under the PG[25] income threshold only account for 49 per cent of the fuel poor on the full income definition.

Table 8: Relative distributions of energy poverty indicators

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[24] This idea draws on a suggestion by Professor Dave Gordon, at the University of Bristol, for which we are grateful.
[25] Consumer Focus, Reaching the fuel poor, Making the Warm Home Discount work, 2011

Household composition	EHCS 2007 Full income definition		2010 CF Nowcast[26]		High relative fuel spending		Under-consumption 40% threshold	
	Count	Column %	Count	Column %	Count	Column %	Count	Column %
Couple, no children, <60	190,008	6.7%	276,919	6.9%	359,017	8.8%	754,782	16.5%
Couple, no children, >60	421,600	15.0%	695,273	17.3%	600,524	14.7%	727,169	15.9%
Couple with children	263,820	9.4%	369,983	9.2%	742,522	18.2%	934,638	20.4%
Lone parent with children	247,999	8.8%	373,484	9.3%	574,665	14.0%	279,205	6.1%
Other multi-person household	176,335	6.3%	244,792	6.1%	279,932	6.8%	365,060	8.0%
One person <60	552,287	19.6%	683,453	17.0%	691,936	16.9%	707,473	15.5%
One person >60	966,652	34.3%	1,377,071	34.2%	842,066	20.6%	807,289	17.6%
TOTAL	2,818,701	100.10%	4,020,975	100.00%	4,090,662	100.00%	4,575,616	100.00%

Table 8 shows how three versions of the fuel poverty "problem" are distributed across household types:

- Fuel poverty in its current definition based on the need for high fuel spending relative to income (full income definition) is particularly pronounced among older people. Single households and couples over 60 comprise 48% of fuel poor households on this measure, whereas only 18% are families with children.
- In contrast, *actual* high relative fuel spending is more widely distributed. Similar proportions of those affected (35% and 32% respectively) are pensioners and children.
- Similarly, older people comprise a third (33.5%) of households under-consuming fuel, despite comprising half of households in fuel poverty. However, only a quarter of these under-consumers are families with children, who have relatively high ratios of fuel consumption compared to need, appearing to prioritise fuel spending (see Figures 10 and 16 above). On the other hand, couples without children under 60 comprise a much greater proportion of under-consumers (16.5%) than households in fuel poverty (7%).

Part of the explanation for the fuel poverty measure showing proportionately higher incidence among older people than the other measures shown here is that it is based on a measure that is more comparable to 'before housing cost' (BHC) income. Non-pensioners tend to have higher housing costs than pensioners, and therefore a BHC measure overstates their disposable income, after paying rent or mortgage, relative to that of pensioners. The 'after housing costs' measures used in this paper's analysis give a better idea of the size of the available household budget from which fuel spending must be taken.
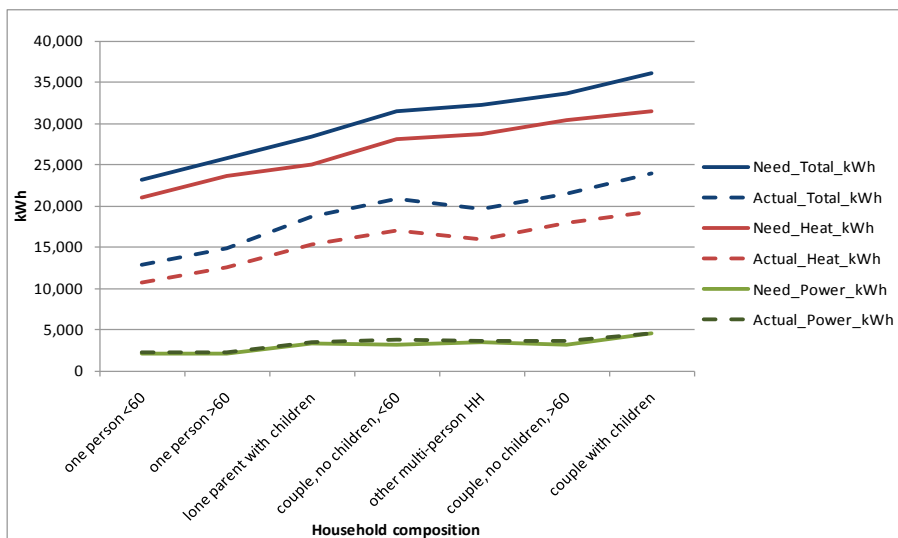
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[26] CSE, Nowcast of Fuel Poverty in 2010, Report to Consumer Focus

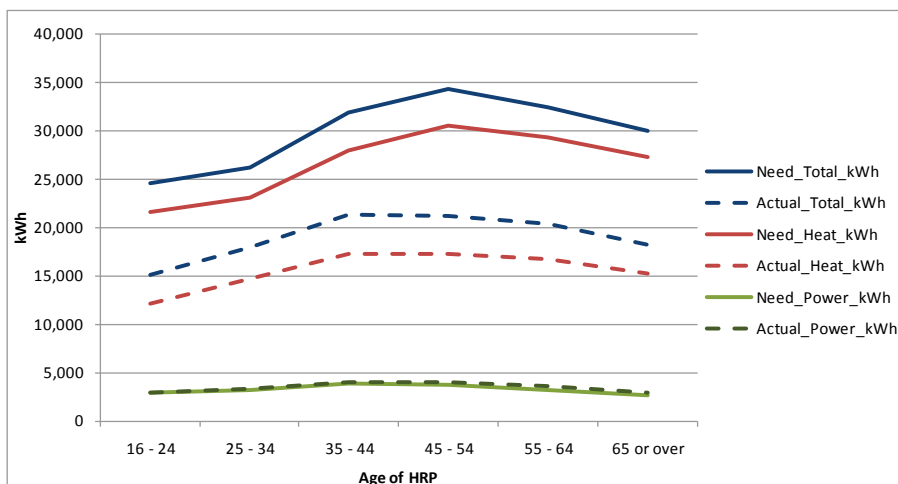# Annex I – Energy consumption by socio-demographics

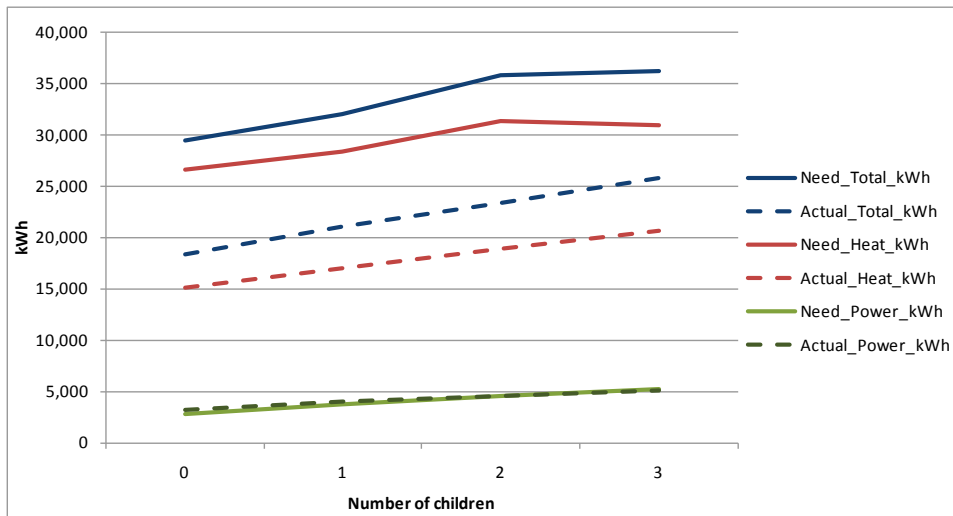## Mean annual energy consumption by income decile (AHC equivalised)
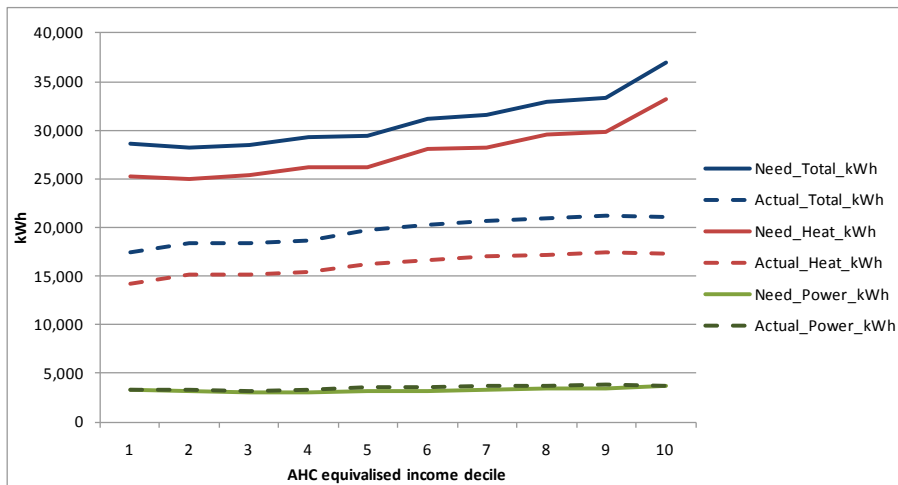
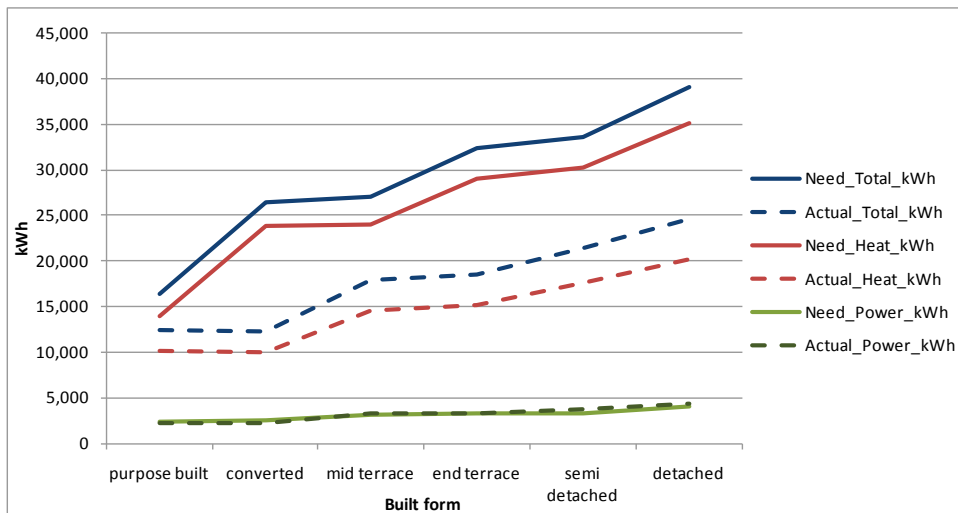## Mean annual energy consumption by household composition

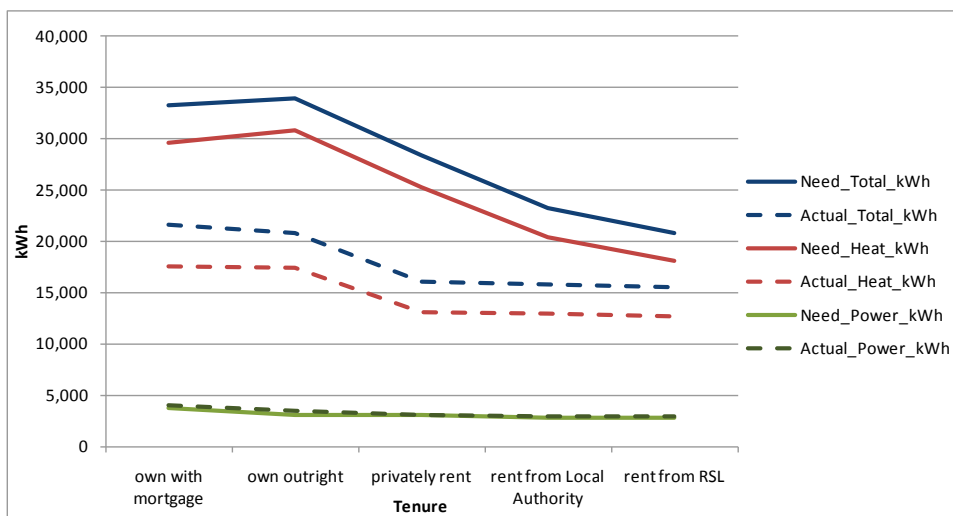## Mean annual energy consumption by age of HRP

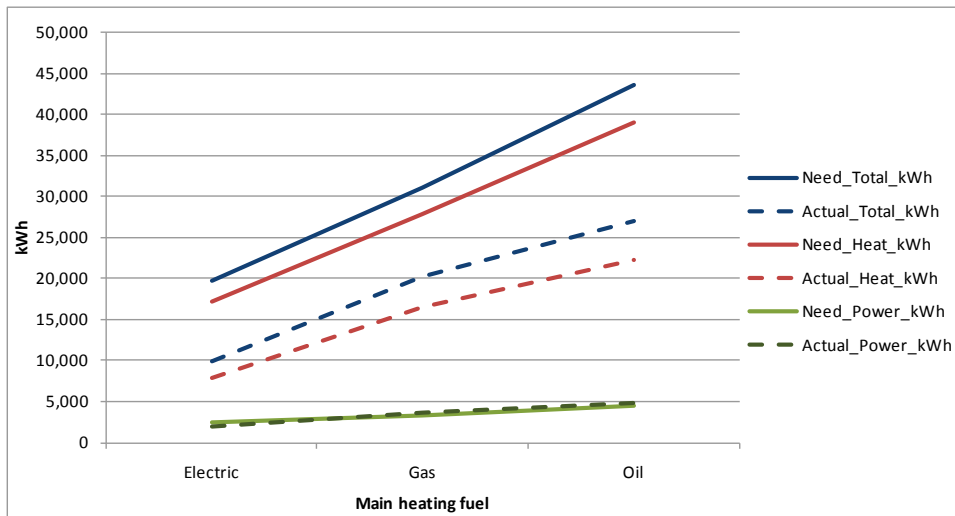## Mean annual energy consumption by number of children
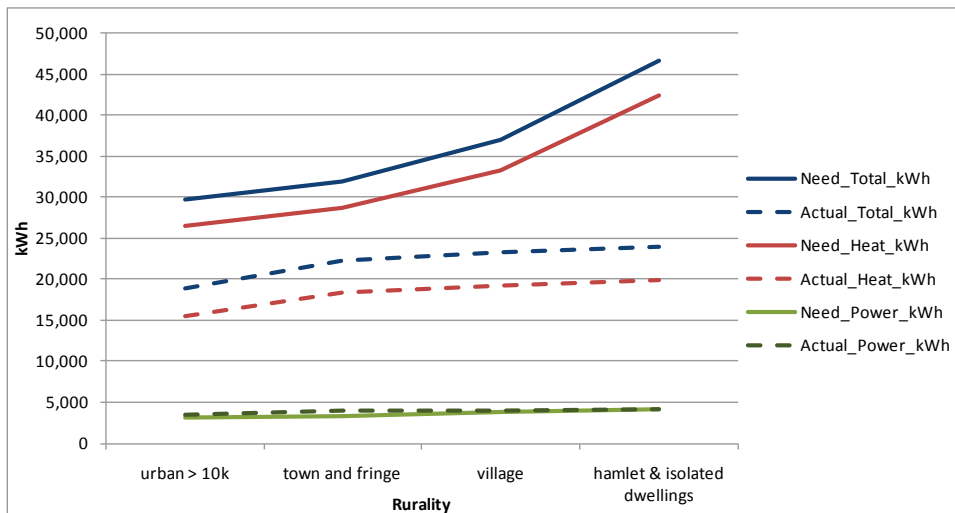

Mean annual energy consumption by dwelling type
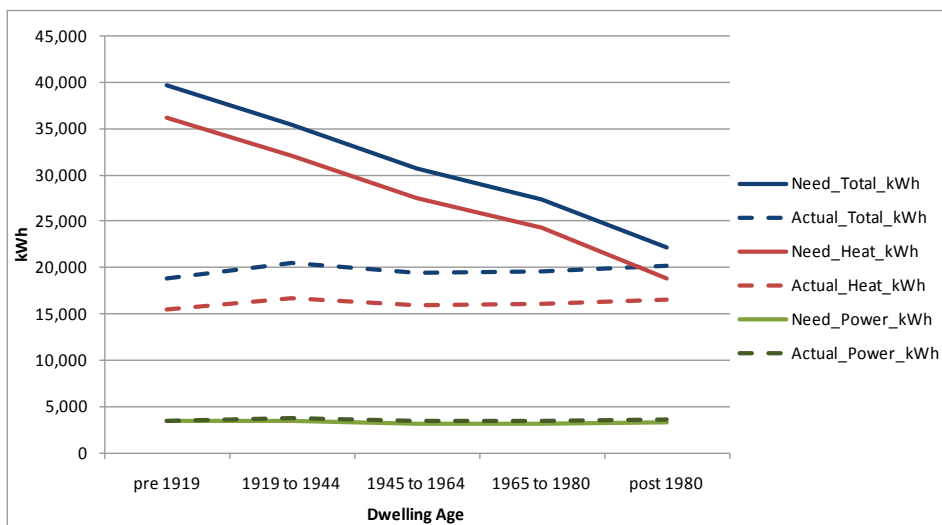

Mean annual energy consumption by tenure

Mean annual energy consumption by main heating fuel

Mean annual energy consumption by rurality
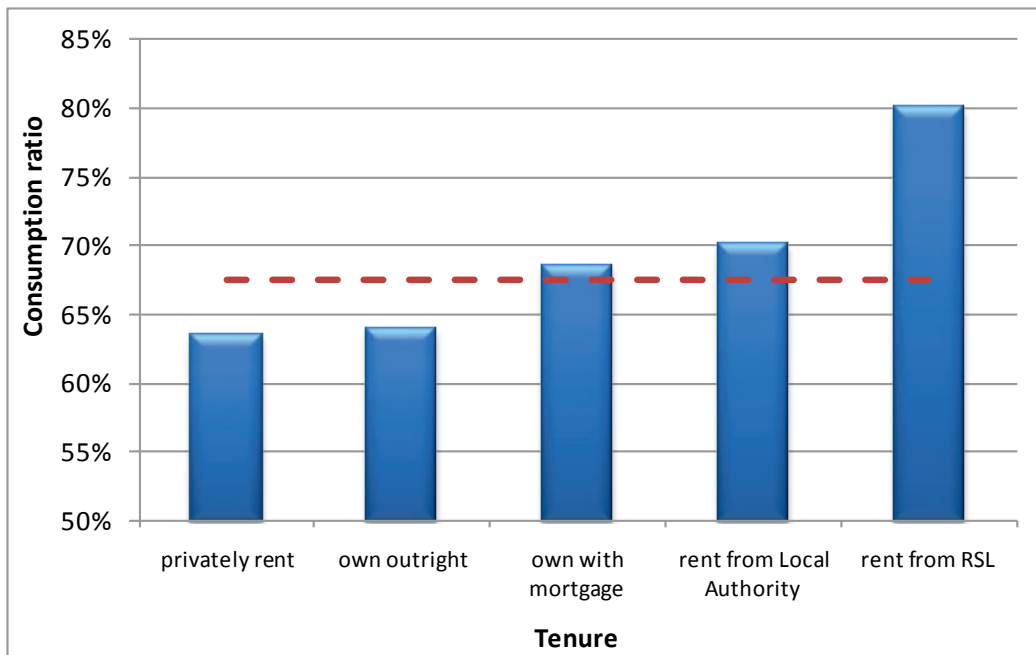

Mean annual energy consumption by dwelling age

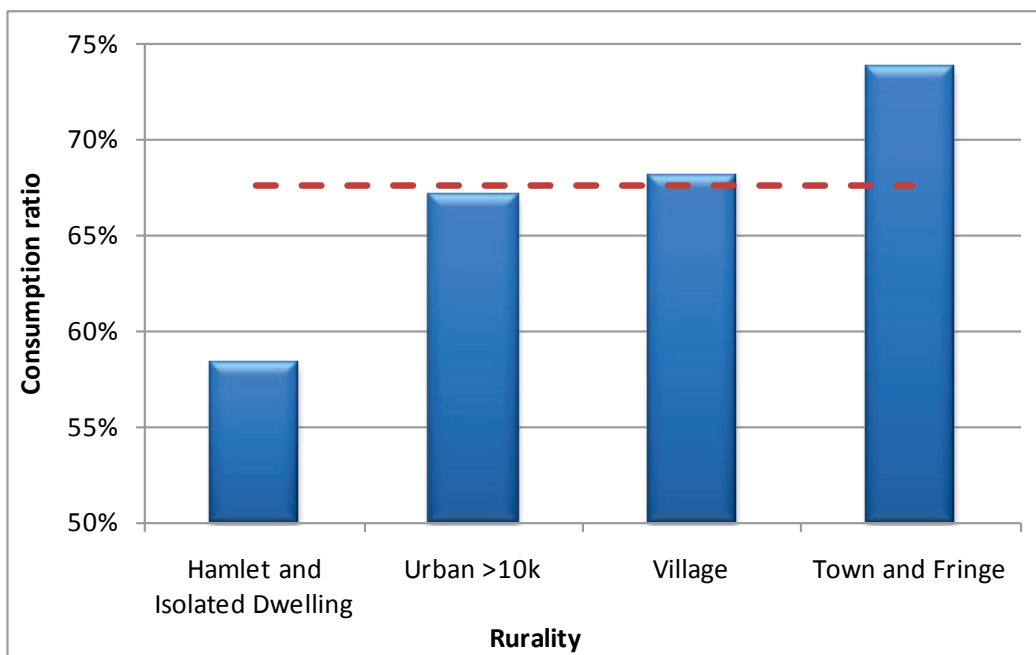**Annex Table 1: Mean kWh values by Actual and Need Heat deciles.**

Decile	Actual Heat kWh	Need Heat kWh
1	6,172	9,892
2	9,246	15,146
3	11,148	18,585
4	12,828	21,474
5	14,405	24,232
6	16,041	26,944
7	17,836	29,952
8	20,088	33,938
9	23,171	39,611
10	30,595	57,198

Annex II – Consumption ratio by socio-demographics

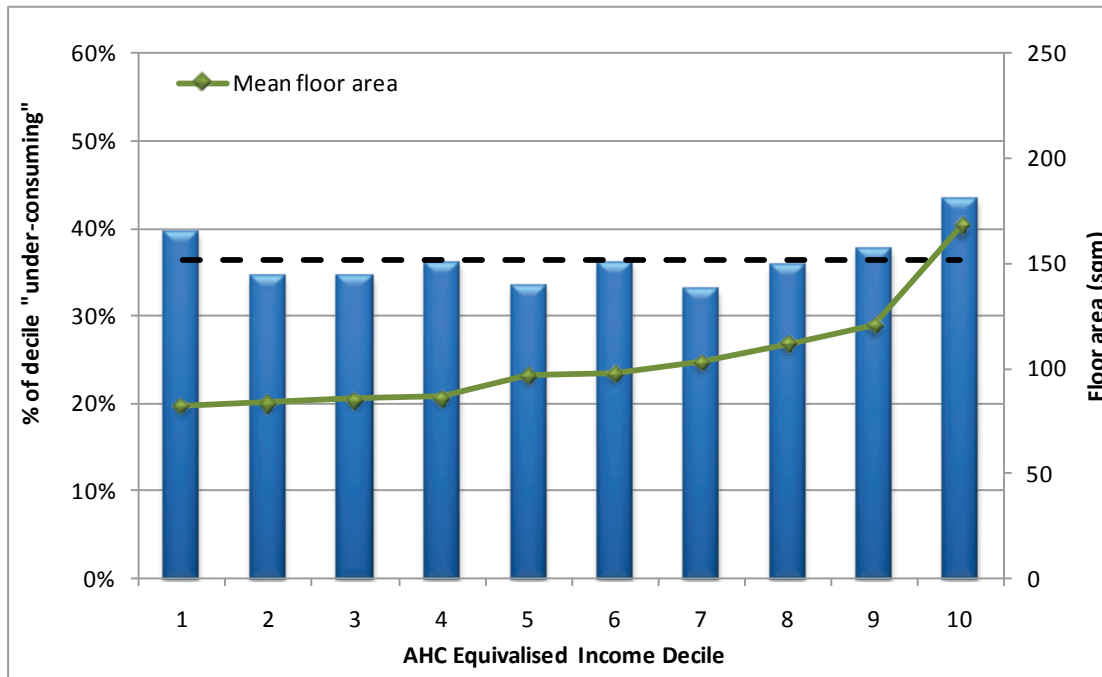**Mean consumption ratio by tenure**

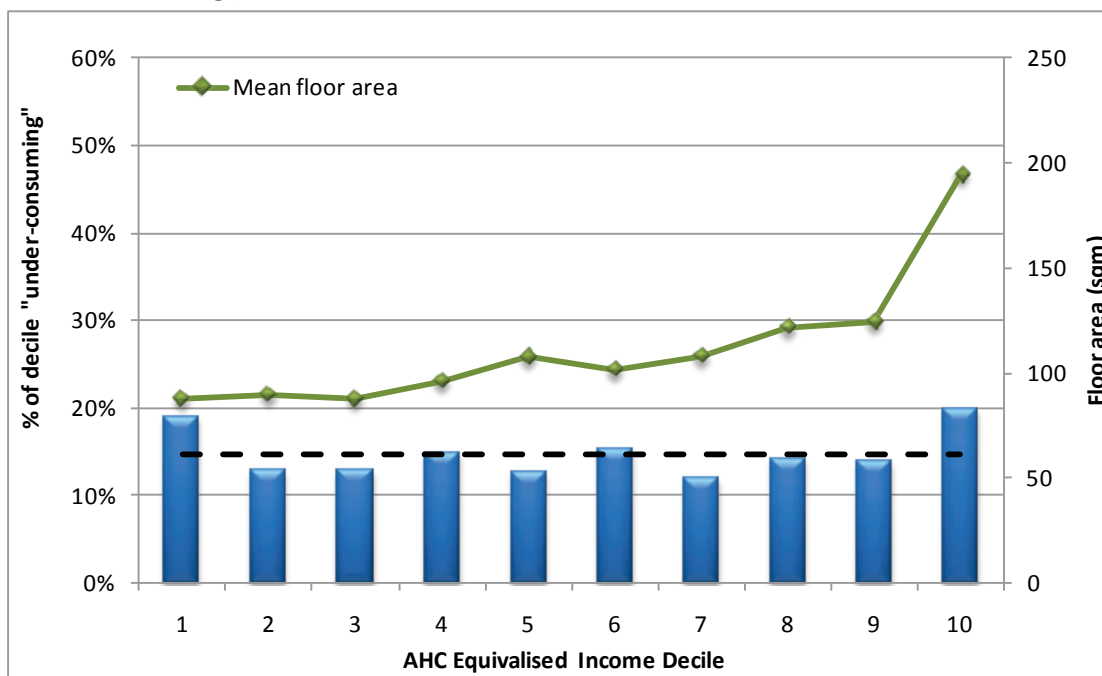**Mean consumption ratio by rurality**

Annex III – Exploring the distribution of different under-consumption thresholds across income deciles

Proportion of households below the 50% threshold (all households with CR<50% defined as 'under-consuming')

Proportion of households below the 35% threshold (all households with CR<35% defined as 'under-consuming')

Annex IV – CHAID results

The dependent variable in the CHAID model is the consumption ratio (actual heat kWh / need heat kWh). The predictor variables entered into the model have been limited to the harmonised variables used in the initial imputation of actual consumption values from the LCF Survey to the EHCS.

CHAID creates clusters – or 'nodes' – of cases (households) that have similar defining socio-demographics (the predictor variables) with respect to the dependent variable. Nodes are assigned a predicted value for the dependent variable (equal to the mean for the group as a whole). The CHAID model applied here identified 37 terminal nodes, of which 19 have a predicted consumption ratio less than the mean for the dataset as whole (0.68) and 12 with a predicted value below the median (0.60). The characteristics of the groups identified as the highest under-consumers (i.e. with the lowest predicted consumption ratio values) are described in the main body of the report.

Annex Table 2: Model Summary

Specifications	Growing Method	EXHAUSTIVE CHAID
	Dependent Variable	Consumption_ratio
	Independent Variables	GOR (harmonised), Urban/rural England and Wales (harmonised), Number of children (harmonised), Number of persons (harmonised), Household type (harmonised), Dwelling type, Tenure of household, Percentile Group of AHCinc, Age of HRP (harmonised), Gender of HRP (harmonised), Employment status of HRP (harmonised), Number of bedrooms - occupied (harmonised), DIMPSA heat fuel
	Validation	None
	Maximum Tree Depth	8
	Minimum Cases in Parent Node	300000
	Minimum Cases in Child Node	300000
Results	Independent Variables Included	Dwelling type, Household type (harmonised), DIMPSA heat fuel, Urban/rural England and Wales (harmonised), Age of HRP (harmonised), GOR (harmonised), Number of children (harmonised), Number of bedrooms - occupied (harmonised), Tenure of household, Percentile Group of AHCinc, Gender of HRP (harmonised)
	Number of Nodes	73
	Number of Terminal Nodes	37
	Depth	8

Annex Table 3: CHAID node counts

Node ID	Count	N %	Predicted Value (CR)
9	436,500	2%	.41
16	312,835	1%	.46
58	391,542	2%	.46
71	321,154	2%	.51
30	463,584	2%	.51
15	441,460	2%	.53
48	573,339	3%	.54
72	349,232	2%	.54
43	607,185	3%	.55
62	302,133	1%	.55
67	357,427	2%	.56
32	321,955	2%	.59
41	509,681	2%	.61
46	368,450	2%	.64
61	4,537,660	21%	.65
56	380,396	2%	.66
54	535,633	3%	.66
11	416,947	2%	.66
68	1,027,121	5%	.67
70	332,657	2%	.68
65	748,458	4%	.70
59	642,202	3%	.71
24	347,557	2%	.71
64	1,093,911	5%	.73
63	460,803	2%	.75
69	466,587	2%	.78
55	310,908	1%	.78
66	347,375	2%	.78
60	316,801	1%	.79
12	413,826	2%	.80
40	658,067	3%	.80
34	546,979	3%	.81
49	464,300	2%	.84
27	461,269	2%	.87
33	449,347	2%	.92
21	363,067	2%	.94
22	301,729	1%	.98

Annex V – Actual fuel spend relative to income

Mean ratio of actual energy spend to income by tenure
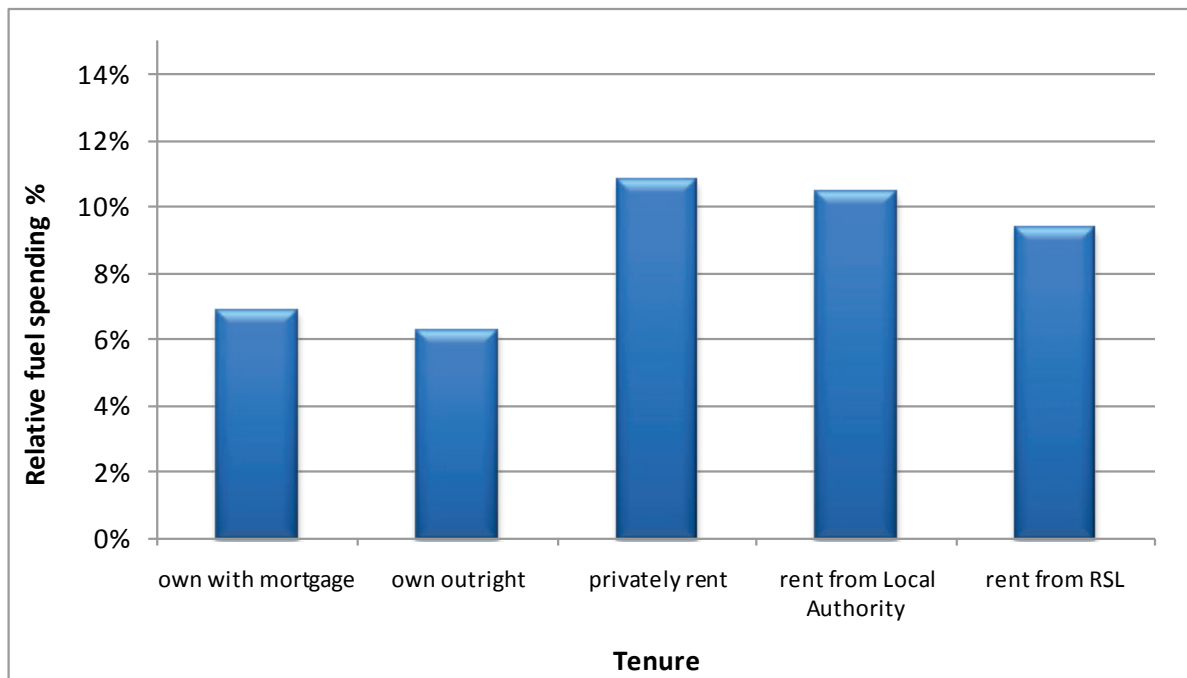
Mean ratio of actual energy spend to income by rurality