Energy Follow Up Survey: Fuel poverty

Final report

The EFUS 2017 has been undertaken by BRE on behalf of the Department for Business, Energy & Industrial Strategy (BEIS).

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Contents

Executive Summary

This report presents the overall findings of the 2017 Energy Follow-Up Survey (EFUS), based on interviews conducted in the autumn of 2017 (Interview 1), the winter of 2017/2018 (Interview 2), and the winter of 2018/2019 (Interview 3). This report brings together the comparative findings for fuel poor and non-fuel poor households from all EFUS 2017 reports. In this study fuel poverty is measured under the 'Low Income High Costs' metric.

A household is fuel poor if:

- The amount they would need to spend to keep their home at "an adequate standard of warmth" is above the national median level.
- And if they spent that amount, their leftover income would be below the official poverty line.

The main findings from this report are presented below:

Household energy consumption and affordability

- The median gas consumption figures for fuel poor and non-fuel poor households were 13,300 kWh/year and 12,200 kWh/year respectively.
- The median electricity consumption figures for households where electricity was not the main heating fuel was 3,400 kWh/year for fuel poor households and 2,900 kWh/year for non-fuel poor households, and 6,800 kWh/year for fuel poor households and 7,100 kWh/year for non-fuel poor households where electricity was the main heating fuel.
- Comparing the average daily gas consumption for the coldest week in winter 2018/19 and the week prior to this, indicative findings suggest fuel poor households were less likely (44%) to increase their gas consumption by 5% or more than non-fuel poor households (70%).
- Fuel poor households were more likely (31%) to under-consume than non-fuel poor households (19%). Fuel poor households were also less likely (7%) to over-consume than the non-fuel poor households (21%)[1].
- Fuel poor households were more likely (40%) to report struggling to keep up with their energy bills compared with the non-fuel poor (16%). In addition, fuel poor households were more likely to cut back on spending (81%) or borrow money or miss a rent/mortgage payment (36%) than non-fuel poor households (60% and 19% respectively).

[1] Households were defined as 'under-consuming' if relative to other households the percentage difference in modelled and actual energy consumption was in the lowest quintile (using less energy than modelled), and households were classified as 'over-consuming' if the percentage difference was in the highest quintile (using more energy than modelled).

Thermal comfort, ventilation, damp and mould

- Fuel poor householders were around twice as likely to feel uncomfortably cold in their living rooms (23%) than non-fuel poor householders (11%).
- Fuel poor households were more likely to feel uncomfortably cold in the main bedroom (16%) than non-fuel poor households (9%). No significant differences in internal temperatures in the living room and main bedroom were observed when comparing by fuel poverty status.
- Fuel poor households were significantly more likely (42%) to report issues of damp and mould than non-fuel poor households (25%).

Heating patterns and occupancy

- The main heating system was reported as a non-central heating system in 16% of fuel poor households, compared with only 7% for non-fuel poor households.
- Fuel poor households were less likely (77%) than non-fuel poor households (84%) to use mains gas as the fuel for their main heating system. Fuel poor households were more likely (15%) to use electricity as the fuel for the main heating system than the non-fuel poor (6%).
- Fuel poor households were less likely (14%) to report changes in their daytime occupancy across different weekdays, compared with non-fuel poor households (23%). Regarding differences between typical weekday and weekend days, fuel poor households were less likely (37%) to report keeping the same daytime occupancy hours for both weekdays and weekends compared with the non-fuel poor (48%).
- The fuel poor were almost twice as likely (13%) to heat their water with an electric immersion heater than the non-fuel poor (7%).

Lights and appliances

- Households not in fuel poverty were significantly more likely (54%) to own low energy LED bulbs than those in fuel poverty (43%).
- Households not in fuel poverty were significantly more likely (46%) to own dishwashers than households in fuel poverty (32%).
- Fuel poor households were more likely (46%) to own a games console than non-fuel poor households (35%).

Fuel poverty churn

- The fuel poverty status of households at Interview 3 was updated based on dwelling improvements, and occupant and income changes since the EHS; this led to 3% of cases to move into fuel poverty and 4% to move out of fuel poverty based on unweighted sample counts.

- Dwelling improvements resulting in a change in modelled energy performance were reported in 12% of households. Of households with dwelling improvements, 9% were found to move out of fuel poverty.
- Changes to household income since the EHS caused income to increase in 16% of households, leading to 13% of these households to move out of fuel poverty. In addition, changes caused incomes to decrease in 27% of households which then led to 8% of cases moving into fuel poverty.

1. Introduction

There is an ongoing requirement to keep our knowledge and understanding of domestic energy use up to date. This is essential to ensure that policies, and policy interventions, are directed in the most efficient and effective manner; that legislation and standards are based on principles and assumptions that reflect how people are actually using energy in their homes; and that models and statistics which provide the underpinning evidence base in this area are as accurate as possible. Of particular relevance at the moment are policies relating to fuel poverty, decarbonisation of heat, smart metering, and minimising household energy bills.

The data presented here is from the 2017 Energy Follow-Up Survey (EFUS). This was a follow-up survey of a sample of respondents from the English Housing Survey (2014-2017) and provided more detailed information on use of heating, hot water and appliances. Similar Energy Follow-Up Surveys were carried out in 1998 and 2011.

Today the Department of Business, Energy and Industrial Strategy (BEIS) has several overarching aims which need to be addressed by this new EFUS. These are:

- To determine current domestic energy consumption and heating patterns in England and to investigate how they change over time through timeseries comparisons.
- To understand how and why there are variations in energy consumption between similar dwellings, and similarities in energy consumption between different dwellings.
- To understand how households in fuel poverty use energy and how their energy consumption patterns and behaviours compare with non-fuel poor homes.
- By drawing on the analysis and key findings from the other 2017 EFUS reports, this Fuel Poverty report aims to inform the third overarching aim of the EFUS 2017 research:
- To understand how households in fuel poverty use energy, what causes them to move in and out of fuel poverty, and how their energy consumption patterns and behaviours compare with non-fuel poor homes.

This report examines the key comparative findings for fuel poor and non-fuel poor households with regard to their heating and occupancy patterns, hot water systems, household energy consumption, thermal comfort, ventilation and damp, and lighting and appliances. This report also includes additional comparisons of fuel poor and non-fuel poor households and aims to bring together and contextualise the findings from across the EFUS, as they relate to the fuel poor. Furthermore, this report will place the results in the perspective of the fuel poverty definition and strategy, contributing to the Government's commitment to regularly review this strategy[2].

2. Methodology

Full details of the data collection and analysis methods used is set out in a separate methodology report, however, an outline is given below of the analysis, the interview surveys upon which this report is based, the meter point data, detailed consumption data, and temperature data.

2.1 Overview of Fuel Poverty

Fuel poverty is defined in the Warm Homes and Energy Conservation Act 2000:

> *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.*

This is formally defined in England using the Low Incomes High Costs (LIHC) indicator, whereby a household is considered to be in fuel poverty if they have required fuel costs that are above the national median, and if they were to spend the amount needed to meet their energy requirements, they would be left with a household income below the official poverty line. Households in fuel poverty are also measured based on a fuel poverty gap – the difference between the modelled energy bill and what their energy bill would need to be for them to no longer be in fuel poverty. There are three key factors used to determine whether or not a household is fuel poor: income, energy requirements, and fuel prices.

2.2 Surveys

The first of the householder surveys was undertaken in the autumn of 2017 and is referred to as Interview 1. A pilot survey of 94 households was carried out between May and June 2017, followed by the main survey of 1,867 households. This survey was conducted via a face-to-face interview conducted in the householders' home between August and October 2017. In

[2] Cutting the cost of keeping warm: a fuel poverty strategy for England https://www.gov.uk/government/publications/cutting-the-cost-of-keeping-warm

order to boost the sample, an online version of the same survey was completed by a further 671 households between October and December, giving a total sample of 2,632.

The Interview 1 survey examined a number of areas including;

- Summer thermal comfort
- Cooling behaviours
- Hot water use
- Appliance use
- Lighting
- Energy tariffs and method of payment
- Dwelling improvements
- Changes to the household

The second of the householder surveys, a follow-up survey to Interview 1, was conducted between January and March 2018 and is referred to as Interview 2. To minimise disruption to the householders the survey was conducted via a telephone interview and 1,060 households completed the telephone survey. As with Interview 1, in order to boost the sample an online version of the Interview 2 survey was completed by a further 280 households, giving a total sample of 1,340. Therefore almost 51% of the Interview 1 households also completed the Interview 2 survey.

The Interview 2 survey examined;

- Use of main, alternative and supplementary heating systems
- Winter thermal comfort
- Winter ventilation behaviours
- Damp and mould
- Winter appliance and hot water use
- Lighting
- Trade-offs made by households unable to afford to heat their homes
- Occupancy patterns

The third of the householder surveys, another follow-up survey to Interview 1, was conducted between February and March 2019 and is referred to as Interview 3. The survey was conducted via a telephone interview and online survey; 447 households completed the telephone survey and a further 739 households responded online, giving a total sample of 1,186. Some 80% of the Interview 3 surveys had an Interview 1 and Interview 2 survey (944 households), while the remaining 242 households had an Interview 1 survey only. The interview 3 survey collected information on;

- Use of main heating systems including the heating season

- Proportion of the house heated
- Occupancy patterns
- Smart technologies
- Method of payment and tariffs
- Changes to property and household

In addition, a short text message survey was conducted at the end of June 2018 during a particularly hot spell. The purpose of the survey was to assess the effects of the high temperatures on householders' thermal comfort and behaviour. Householders were sent four questions via text message. Of the 1,308 people to whom the text message was sent, between 353 and 376 responses were obtained for each question (27-29% of those sampled). There is the prospect of response bias in the results reported from the text survey, in particular, that those experiencing overheating might be more likely to respond to questions about the subject.

The results presented in this report are based on the householder responses to questions from all Interview surveys and explores the key findings for fuel poor and non-fuel poor households. The respective survey is referenced within the text.

2.3 Meter Point Data

Meter point data was provided by the BEIS National Energy Efficiency Data-Framework (NEED) team for 2,217 households, covering the period January 2017 through to December 2017 for electricity, and the period June 2017 to June 2018 for gas. After cleaning and validation, the resultant datasets contained information on 1,994 households with valid electricity data (93 households with solar PV were excluded), and 1,770 cases with gas data. Both the electricity data and gas data has been annualised, and the gas data has also been weather corrected. Further guidance on how this data was collected can be found here: https://www.gov.uk/government/publications/regional-energy-data-guidance-note.

The total gas and electricity consumption figures have been produced for 1,919 households with available gas and electricity data (or just electricity data where the household is not on the gas network).

2.4 Detailed Consumption Data

As part of interview 1, households could opt to have their gas and/or electricity consumption monitored using devices that attach to the gas/electricity supply near the meter and monitor flow every half an hour (in the case of gas) and every two seconds (for electricity).

Detailed gas and electricity consumption data was collected from January 2018 to May 2019, with monitors installed in households between January 2018 and October 2018. The large time frame over which the installations occurred means there are different amounts of consumption data recorded for each household. In order to minimise large variations in the amount of data being analysed for each household a detailed consumption monitoring period was defined; from 1st May 2018 to 30th April 2019. This period maximises the data available for analysis over the EFUS heating season, particularly relevant for the gas consumption data, while also covering a full year of data.

Valid gas consumption data was collected in 143 households across the detailed consumption monitoring period, the amount of data available to analyse for each household ranges from 4 months of data to a full year. Gas consumption data was collected every 30 minutes for each monitored household and these readings were summarised and averaged for analysis. Values calculated include:

Daily averages for each household, calculated by summing the gas consumption each day to a daily total, then averaging these daily totals across a time period of interest.

Hourly averages for each hour in the day for each household, calculated by averaging the half hourly values into an hourly value, then averaging across all days in which data is recorded for that hour over a time period of interest.

Valid electricity consumption data was collected in 436 households across the detailed consumption monitoring period. Electricity consumption data was collected every two seconds for each monitored household and these readings were summarised and averaged for analysis, including daily averages for each household and hourly averages, calculated using the same method as for the gas data, as outlined above.

2.5 Temperature Data

Temperature loggers were installed in 750 households from August 2017 until October 2017 and internal temperatures were monitored up until April 2019. Temperatures were recorded in up to five rooms in any one household; the living room, hallway, main bedroom and second and third bedrooms (if present). Weather data was obtained from the Met Office (MIDAS dataset). The Met Office station closest to each household was identified, and the hourly external temperatures recorded by each station were time-matched to the temperature data recorded by the loggers.

Data was processed to calculate monthly and seasonal averages, including average temperatures during the coldest week of the year. Average internal temperatures were calculated for each room with data.

2.6 Weighting

The weighting factors for all three interview surveys were derived using a RIM weighting method and logistic regression, based on population targets so that each household in the EFUS dataset represent the number of households in England in 2017 (23.95 million) and 2018 (24.17 million). Additional weighting factors were derived for each subset of households with valid temperature logger data, valid electricity data, gas data, and combined electricity and gas data. Further details are provided in the separate methodology report.

2.7 Fuel Poverty Status

Prior to analysing the EFUS data for fuel poor households any dwelling and household changes which may affect fuel poverty status had to be identified. Fuel poverty calculations were made at Interview 1 and at Interview 3.

Such changes include dwelling improvements, changes to household composition, changes in tenure, and changes to income. Householders were asked a variety of questions on these items and their responses were used, in conjunction with the original base EHS data, to calculate the fuel poverty status of each case at the time of the EFUS survey.

Where households reported carrying out improvements to their dwellings since the original EHS, the original EHS fuel cost calculations (both SAP and BREDEM) were repeated, incorporating these improvements to the dwelling. The dwelling improvements were loft insulation, cavity wall insulation, solid wall insulation, floor insulation, installation of a new boiler, new storage heaters, solar hot water, solar photovoltaics, and at Interview 3, double glazing.

Householders were also asked if the people permanently living in the home were the same as those living there when the last EHS took place. Any households that reported changes were then asked who (if anyone) had moved out, and the name, age, and sex of any new people who had moved in. This information was used to derive new income and fuel cost equivalisation factors (factors that adjust incomes and fuel costs according to household size and composition under the fuel poverty methodology).

Any households that recorded a change in tenure were also assigned updated housing costs, while households that reported a change to their income (HRP and partner income, or additional adults) had a new household income variable calculated as a net income (after tax) for all members of the household. In addition, at Interview 3, reasons for any change in income since the EHS were recorded, to enable further validation and analysis of the reasons for movement in and out of fuel poverty (fuel poverty churn).

The fuel poverty statistics for households in England are calculated on an annual basis, as an indicator for a certain point in time, making it difficult to compare a household’s fuel poverty status across several years. Rather than deriving a new fuel poverty indicator using EFUS data, the fuel poverty thresholds that had already been calculated in the EHS were used. Where a new total household income was calculated, a deflator was applied for each year since the EHS survey took place, reflecting the average increase in income as observed in the EHS from 2014 to 2016. Households that reported no changes kept their total household income as calculated in the EHS.

Having adjusted each of the components of the fuel poverty status, a new fuel poverty variable was calculated for all households, using the updated information from EFUS 2017 as appropriate. The methodology described above to derive the fuel poverty status was the same for households from Interview 1 and Interview 3, with slight differences in the calculation of new household incomes between interviews, and extra information collected at Interview 3.

For further analysis of the fuel poor, a categorical fuel poverty gap variable was derived by splitting cases into three weighted bands of equal size. The fuel poverty gap for households at Interview 3, when split into ‘low’, ‘medium’ and ‘high’ categories, were as follows: ranging from £0 to £160 in the lowest band; between £160 and £400 in the medium band; and ranging from £400 to £2,800 in the highest band.

2.8 Analysis

Statistical analysis was used to measure the significance of the findings presented in this report. All statistical analysis was conducted on weighted data, and a design effect factor was used to account for the complex survey design. Further detail on the analysis is provided in the full methodology report.

The key dependent variables used in each chapter have been analysed by fuel poverty status and the fuel poverty gap. Only statistically significant results have been included in the text unless explicitly stated otherwise; it can therefore be assumed by the reader that characteristics not mentioned showed no significant differences. All significant results are reported at either the 99% level (where $p < 0.01$) or the 95% level ($p < 0.05$), depending on the analytical approach undertaken in each of the other EFUS 2017 reports. It is important to note that small sample sizes preclude detailed analysis of the fuel poor. The following tests were used:

The Chi-Squared (X2) test was used when comparing two categorical variables to determine if they are independent. Alongside this the Z-test for proportions was used to determine where the differences occur, with a Bonferroni correction. Cramer’s V test was used to analyse the effect size.

Analysis of Variance (ANOVA) was used with continuous data to determine the impact of categorical variables, and the Tukey post-hoc test was used to determine where the differences occur. In addition, the effect size Eta-squared (η2) has been calculated. Where assumptions for homogenous variances are violated, the result of the Welch test has been reported, and post-hoc testing has been conducted by independent t-tests.

The Kruskal-Wallis test was used for non-parametric analysis of continuous or discrete data, to determine the impact of categorical variables. The Mann-Whitney U test was used to determine where differences occur, and the effect size was approximated based on the r statistic.

All frequencies and percentages reported in the text have been rounded, with percentages rounded to the nearest percent. Annual consumption figures have been rounded to the nearest 100 kWh/year, and fuel costs rounded to the nearest £10. Measured temperatures have been rounded to the nearest tenth of a degree (°C).

In this report, where householders responded ‘don’t know’ to a question, and if the proportion of ‘don’t know’ responses was less than 5% of the unweighted sample then these were set to missing and excluded from the analysis.

3. Characteristics of the Fuel Poor

This chapter provides a profile of the fuel poor, describing some of the key dwelling and household characteristics of the group[3].

3.1 Overview

- The fuel poor were more likely (58%) to live in older dwellings (pre-1944) than the non-fuel poor (34%), similarly the fuel poor were less likely (6%) to live in newer dwellings (post-1990) than the non-fuel poor (19%)
- The fuel poor were more likely (68%) to live in dwellings without insulated walls and less likely (53%) to have >150mm loft insulation, compared with the non-fuel poor (48% and 64% respectively)
- Fuel poor households were less likely (73%) to live in dwellings with full double glazing than the non-fuel poor (86%)
- The fuel poor were more likely (15%) to live in a dwelling with an energy efficiency rating of F or G, compared with the non-fuel poor (3%). Additionally, the fuel poor were less likely (5%) to live in a dwelling with an energy efficiency rating of A to C, compared with the non-fuel poor (35%)
- The fuel poor were almost twice as likely (32%) to be private renters than the non-fuel poor (17%)
- The fuel poor were less likely (53%) to have a smaller household (2 people or fewer) and more likely to have a larger household (5 or more people) (13%), compared with the non-fuel poor (70% and 4% respectively)
- The fuel poor were less likely (19%) to be under-occupying than the non-fuel poor (33%)
- When fuel costs were banded into three weighted categories for fuel poor households, at Interview 3 the median annual equivalised fuel costs were £1,270 for the lowest band, £1,440 for the medium band, and £1,800 for the highest band

[3] Annex tables containing the underlying data for this section can be found in Tables_3_1.xls and Tables_3_2.xls.

3.2 Fuel poverty churn

3.2.1 Fuel poor sample

In total 749 households who took part in EFUS Interview 1 were in fuel poverty at the time of their EHS survey (28% of the EFUS Interview 1 sample). Through modelling of the EFUS Interview 1 data, 649 households (25% of the sample) were calculated as being in fuel poverty and were weighted to population targets resulting in 11% of fuel poor households. At Interview 3, 22% of the sample were calculated as being in fuel poverty, which represents 11% of homes after weighting.

To investigate churn (movement of households in and out of fuel poverty), changes between the EHS survey and EFUS Interview 3 have been analysed. Due to the over-sampling of households in fuel poverty, the remaining analysis in this section has been conducted at the sample level, and therefore can only be regarded as exploratory for the purposes of this report.

3.2.2 Changes since the EHS

The following changes have been used to update the fuel poverty status of households in the EFUS:

- Income changes for the HRP and partner and any additional adults have been used to revise the total household income variable at the time of the EHS survey
- Dwelling improvements that result in a change to the EPC rating have been used to update modelled fuel costs at the time of the EHS survey
- Equivalisation factors have been revised based on the household composition at the time of EFUS Interview 3, using information on occupants who have moved in or out, and children who are now classed as adults within the household[4]
- Household costs have been changed, where there has been a change in tenure with no associated housing costs (rent-free or own outright)

The fuel poverty status at Interview 3 has been calculated based on whether the household at the time of the EFUS would be in fuel poverty in the year of the original EHS survey (2014, 2015, or 2016), to be able to compare the new fuel costs and household income with the published thresholds.

Table 3.1 shows the number of cases with resultant changes to fuel costs, income, equivalisation factors, and housing costs, at Interview 3. The majority of households had some reported change (56%), and of these income differences were most prevalent (43% of cases), followed by occupant changes and new equivalisation factors (17%), and then dwelling improvements (12%). Just 2% of the sample reported a change in tenure that resulted in the removal of housing costs.

[4] Occupancy equivalisation factors can change for the same people in a household if they move into a new age group.

Table 3.1: Changes since EHS to fuel costs, income, occupancy equivalisation factors, and housing costs, at Interview 3[5]

	Sample size	Percent (%)
Income:		
No change	*679*	57.3
Income higher	*186*	15.7
Income lower	*321*	27.1
Fuel costs:		
No change	*1045*	88.1
Fuel cost lower	*141*	11.9
Equivalisation factors:		
No change	*984*	83.0
Factors changed	*202*	17.0
Housing:		
No change	*1166*	98.3
Housing costs reduced	*20*	1.7
Total	***1186***	**100.0**

Base: all households (n = 1,186) Interview 3.

In total, 202 cases had occupant changes since the EHS and subsequently the equivalisation factors used to calculate household equivalised income and equivalised fuel costs were revised with the following impact:

- Lower occupancy equivalisation factors in 39% of cases with occupant changes, resulting in higher equivalised income values and higher equivalised fuel costs than at the time of the EHS
- Higher occupancy equivalisation factors in 35% of cases with occupant changes, resulting in lower equivalised income and fuel costs
- Higher occupancy equivalisation factors in a further 24% of cases with occupant changes resulted in lower equivalised incomes (and the same equivalised fuel costs)

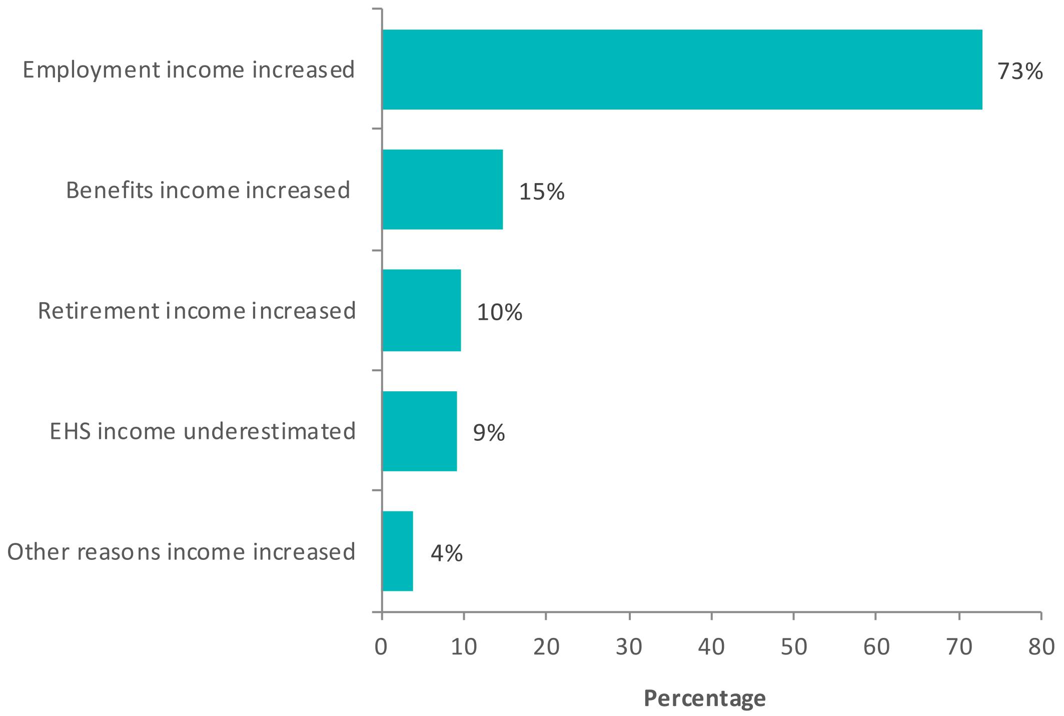
The change in energy performance following dwelling improvements is best described with reference to the change in SAP and EPC bandings. Of the 141 cases reporting a dwelling improvement since the EHS, 27% resulted in a change in energy performance which was sufficient to change the EPC band, while the median reduction in the associated SAP costs was £90. The most frequently reported dwelling improvements leading to a modelled reduction in the SAP costs were new boiler (60%), loft insulation (22%), and floor insulation (10%).

[5] 'No changes' are defined using the following assumptions: **Income**: no reported change in income of >£100/month, **Fuel costs**: no reported dwelling improvements leading to a change in the modelled EPC rating, **Equivalisation**: no household changes leading to an impact on equivalisation factors, **Housing**: housing costs assumed the same as in the EHS.

A large proportion of the sample reported a change to the household full income at Interview 3 (43%), either from HRP and partner income changes, or additional adult income changes, with 186 cases modelled to have a higher fuel poverty full income value compared with the EHS, and 321 a lower income value. In total, 33% of the Interview 3 sample had a change in the monthly HRP and partner income, 5% a change to the additional adult income, and 4% had a change to both income sources.

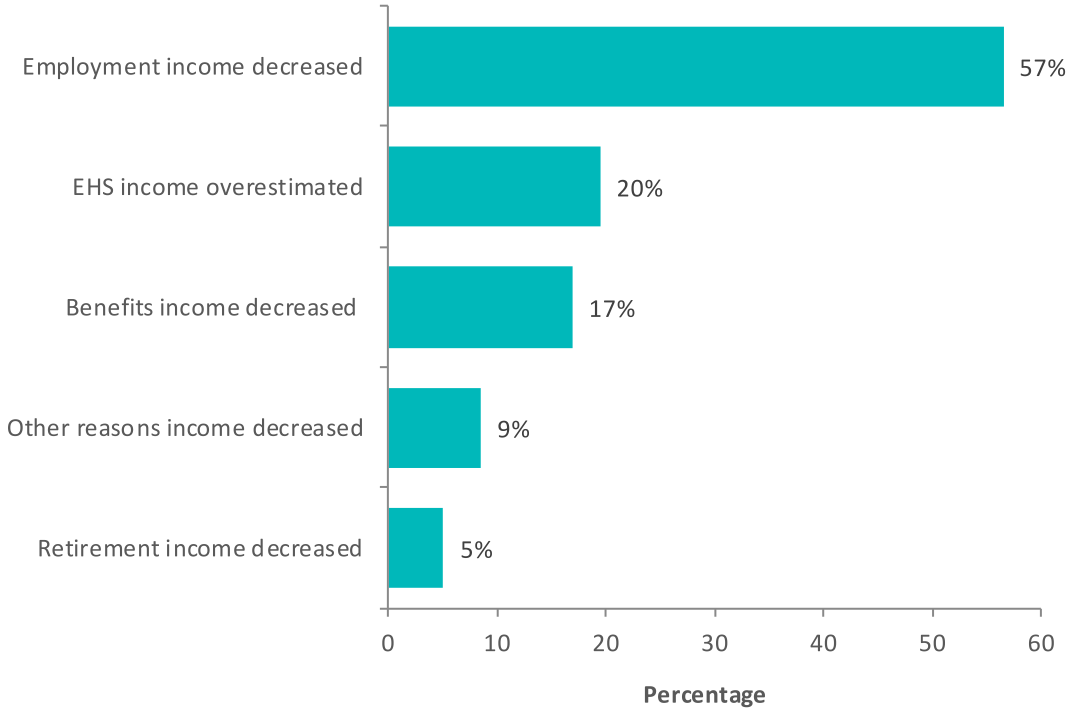
The median HRP and partner income increased by on average £300 per month for households reporting an increase in their income and decreased by £640 per month for households reporting a decrease in their income. Figure 3.1 shows the reasons that HRP and partner incomes increased between the EHS and EFUS Interview 3, and Figure 3.2 shows the reasons that their incomes had decreased.

Figure 3.1: Reasons for increased HRP and partner total income



Base: all households with increase in HRP and partner income (n = 176) Interview 3.

Figure 3.2: Reasons for decreased HRP and partner total income



Base: all households with decrease in HRP and partner income (n = 235) Interview 3.

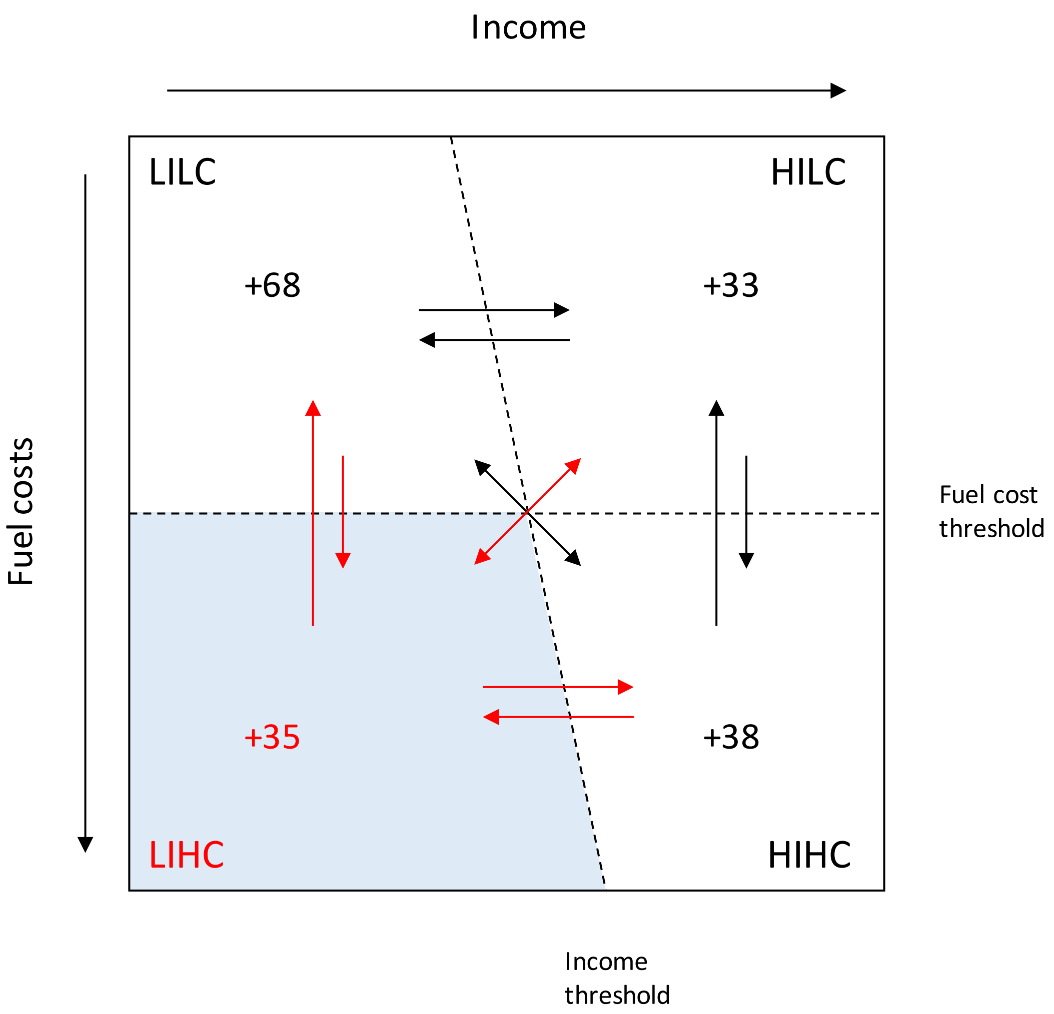
The majority of households with an increase in their HRP and partner total income reported this was due to an increase in employment income (128 cases), with the following reasons reported for this group: salary increase (52%); change in job with higher salary (26%); and working more hours (23%). Where households had reported an increase in income from benefits (26 cases), this was reported to be due to an increase in existing benefits for 42% of these cases. Similarly, the majority of households with a decrease in the HRP and partner total income reported this was due to employment income (133 cases), with the following reasons reported for this group: HRP or partner not employed (35%); working fewer hours (34%); and change in job with lower salary (20%). Of households reporting a decrease in HRP and partner income from benefits (40 cases), for 50% of cases this was due to a reduction in existing benefits.

The number of cases reporting a change in additional adult income since the EHS was small, with 27 cases reporting an increase in additional adult income and 6 cases reporting a decrease. It should be noted however, that there were an additional 71 cases with no reported additional adults at Interview 3 while previously in the EHS an additional adult income was recorded, leading to a reduction in their total fuel poverty income.

3.2.3 Fuel poverty movement

Based on the household and dwelling changes reported above, between the EHS survey and Interview 3, the number of households classed as fuel poor decreased by 15 cases, where 50 cases had moved out of fuel poverty, and 35 cases had moved into fuel poverty. The majority of cases remained in the same fuel poverty quadrant as at the time of the EHS (85%). The largest changes were observed between the following groups: high income low cost to low income low cost (48 cases); low income high cost to high income high cost (32 cases); and high income high cost to low income high cost (29 cases). A breakdown of movement into each quadrant are illustrated in Figure 3.3 below.

Figure 3.3: Movement of households across the fuel poverty quadrants, between the EHS survey and Interview 3



Base: all households at Interview 3 (n = 1,186).

Due to the overlap of different household and dwelling changes, it is not possible to simply differentiate between changes and the resultant effect on the fuel poverty status of households. In addition, changes to equivalisation factors cause a mixed effect on the likelihood of a household moving into fuel poverty. For example, an increase in the number of people in the household generally leads to an increase in equivalisation factors, which leads to a reduction in the After Housing Cost (AHC) equivalised income and a reduction in equivalised fuel costs. This could push a household across the income threshold into low income, or across the fuel costs threshold out of high costs.

By analysing the fuel cost and income changes, and corresponding movement between fuel poverty quadrants, the following were identified:

- Dwelling improvements caused 15% of cases to move out of high costs, with 9% moving directly from LIHC to LILC
- Increases in income caused 23% of cases to move out of low income, with 13% moving directly from LIHC to HIHC
- Decreases in income caused 23% of cases to move out of high income, with 8% moving directly from HIHC to LIHC

4. Household Energy Consumption and Affordability

This section of the report explores household energy consumption using meter point data and detailed gas consumption data and will also comparatively investigate fuel poor and non-fuel poor households in terms of their household energy costs and affordability[6].

4.1 Energy Consumption

It might be anticipated that the fuel poor would use less energy compared with the non-fuel poor, simply due to an inability to afford their energy demand. A simple comparison does not however, reflect the differing attitudes and behaviours and household characteristics that exist both between and among both fuel poor and non-fuel poor households, nor the different types of dwellings they live in. The impact of these differences on energy consumption are considered within multivariate analysis in section 4.2. More informative is a comparison of the metered (actual) consumption of fuel poor homes, and the modelled fuel consumption used in the calculation of a fuel poor household's fuel poverty status (section 4.6).

The median gas and electricity consumption figures, based on English households with valid consumption data in 2017, split by fuel poverty status and the banded fuel poverty gap indicator are shown in Table 4.1. The median gas and electricity[7] consumption figures for fuel poor households were 13,300 kWh/year and 3,600 kWh/year respectively and 12,200 kWh/year and 3,000 kWh/year respectively for non-fuel poor households. The interquartile range (IQR) of consumption for households with a lower fuel poverty gap was 6,400 kWh/year for gas and 1,800 kWh/year for electricity, while the IQR for households with a higher fuel poverty gap was almost double that for gas, at 12,400 kWh/year, and almost triple for electricity at 5,200 kWh/year.

Exploring electricity consumption further by main heating fuel type and fuel poverty status, fuel poor households where electricity was not the main heating fuel had a median consumption of 3,400 kWh/year, while non-fuel poor households had a median consumption of 2,900 kWh/year. Where electricity was the main heating fuel, fuel poor households had a median consumption of 6,800 kWh/year and non-fuel poor households had a median consumption of 7,100 kWh/year.

[6] Annex tables containing the underlying data for this section can be found in Tables_4.xls.
[7] Median electricity consumption figures are for all households, including households using electricity as the main heating fuel.

Table 4.1: Annual gas and electricity consumption in 2017, by fuel poverty status and banded fuel poverty gap indicator.

	Gas consumption (kWh/year)			Electricity consumption (kWh/year)			Total energy consumption gas and electricity (kWh/year)		
	Sample size	Median	IQR for median	*Sample size*	Median	IQR for median	*Sample size*	Median	IQR for median
Fuel poor	*444*	13,300	(9,800; 17,400)	*538*	3,600	(2,500; 5,500)	*520*	15,300	(10,300; 21,100)
Non-fuel poor	*1326*	12,200	(7,900; 16,500)	*1456*	3,000	(2,000; 4,600)	*1399*	14,000	(9,000; 19,600)
Fuel poor gap:									
Low	*167*	12,200	(8,600; 15,100)	*183*	3,100	(2,200; 4,000)	*179*	14,500	(9,200; 18,900)
Medium	*165*	13,400	(9,700; 17,100)	*195*	3,600	(2,500; 5,400)	*189*	15,300	(10,400; 21,300)
High	*112*	15,500	(11,100; 23,500)	*160*	4,700	(2,800; 8,000)	*152*	16,600	(11,300; 25,900)

Base: all households with meter point data (n = 1,770 for gas mid-June 2017 to mid-June 2018, n = 1,994 for electricity 31st January 2017 to 30th January 2018, n = 1,919 gas and electricity).

The median total energy consumption was calculated for all households with valid gas and electricity meter point consumption data. Fuel poor households had a median total consumption of 15,300 kWh/year and non-fuel poor households had a median total consumption of 14,000 kWh/year. Table 4.1 shows the total energy consumption figures for households with a low, medium, and high banded fuel poverty gap indicator, as well as the lower and upper quartiles.

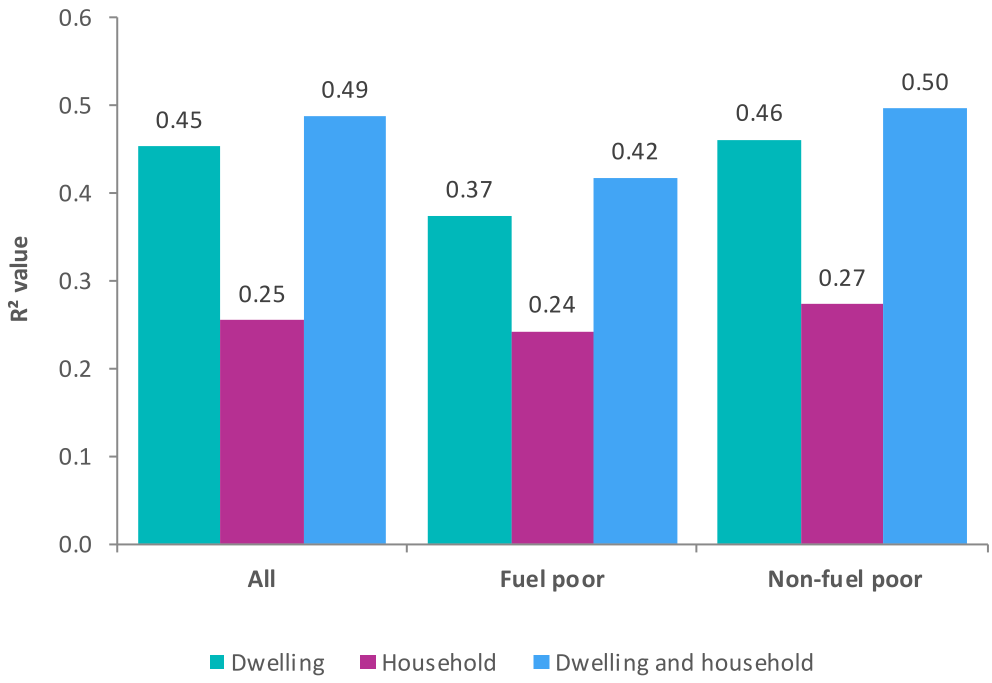
The gas and electricity consumption results obtained from the meter point data indicate that the fuel poor are consuming, on average, more energy than the non-fuel poor. This result is not particularly unexpected, given that under the current definition, the fuel poor have high modelled energy costs.

4.2 Multivariate Analysis of Gas and Electricity Consumption

Based on results from bivariate analysis, for households with gas central heating, at the 95% level, the fuel poor were found to use significantly more gas than households not in fuel poverty. Similarly, for households not using electricity as their main fuel, the fuel poor were found to use significantly more electricity than households not in fuel poverty. It is likely that the characteristics of the fuel poor group are driving these results, therefore multivariate analysis using linear regression was used to identify the key dwelling and household characteristics that explain variability in annual gas and electricity consumption. For the detailed methodology and results of this analysis, see section 3.2.1 and section 3.3.1 in the Household Energy Consumption and Affordability report.

Comparisons were made between the fuel poor and non-fuel poor, when looking at the impact of dwelling and household characteristics on annual gas consumption. Figure 4.1 shows that the same overall patterns were present across the three groups (fuel poor; non-fuel poor; all households) when analysing the extent to which dwelling and household characteristics explain the variability in gas consumption. Dwelling characteristics alone explained more of the variability across all three groups, however when considering the fuel poor group, dwelling characteristics appear to explain less of the variation in gas consumption, than for households not in fuel poverty. These results indicate that it is more difficult to explain the variability in gas consumption for households in fuel poverty, using only known information on dwelling and household characteristics.

Figure 4.1: R2 values for each of the models by fuel poverty status



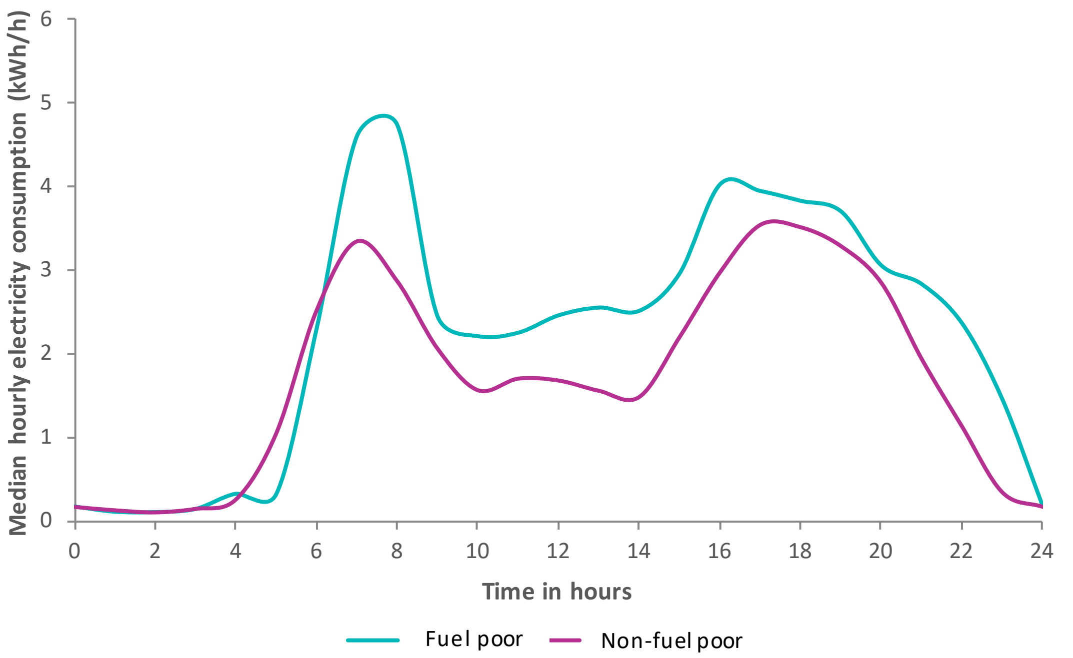
Base: all households with gas central heating and meter point data (n = 1735 for all households, n = 430 for fuel poor, n = 1305 for non-fuel poor).

Regression models were used to analyse the impact of variables on annual electricity consumption. Fuel poverty status was found to be a significant factor in explaining variability in electricity consumption when considered alongside other household characteristics. However, when combined with dwelling characteristics fuel poverty status was no longer a significant factor, indicating that other variables explained more of the variability in electricity consumption.

4.3 Detailed Gas Consumption

A daily profile of gas consumption was produced for all households in the detailed gas consumption sub-set split by fuel poverty status, by taking the median gas consumption for each hour of the day. Indicative results show that fuel poor households had a higher level of consumption than the non-fuel poor, most noticeably in the morning (Figure 4.2). As reported in section 4.2, this result is likely influenced by the composition of fuel poor households, as they are generally larger and in for longer during the day, both factors that promote higher energy consumption throughout the day.

Figure 4.2: Median profile of mean hourly gas consumption for the EFUS heating season, by fuel poverty status



Base: all households with detailed gas consumption data over the EFUS heating season (n = 107).

Note: Fuel poor median profile based on a small sample size, indicative only.

Exploratory analysis[8] was carried out to determine if there were any differences in gas consumption during the coldest week of the year (2018/2019), and the warmer weeks either side of this. Table 4.2 shows the median daily gas consumption figures for the week prior to the coldest week, the coldest week, and the following week (week 1, week 2, and week 3 respectively), when split by fuel poverty status.

Further analysis was carried out on the differences in consumption between week 1 and week 2, to better understand how households responded to changes in external temperature. At the 95% level, non-fuel poor households were notably more likely (70%) to increase their gas consumption by 5% or more, compared with 44% of fuel poor households.

This break in the trend for increasing gas consumption in the coldest week was only observed for fuel poor and low-income households, which could imply an upper threshold to consumption for those in fuel poverty. Affordability of energy is perhaps the obvious possible

[8] Due to small samples, the analysis presented here is unweighted and further work in this area is required to corroborate these findings.

explanation, but other factors, including an inability to increase heat output of their system, may also play a part.

Table 4.2: Median daily gas consumption for the coldest week in winter, and the weeks either side, by fuel poverty

	Median gas consumption and mean external temperatures for three coldest weeks in winter								
	Week 1			Week 2 Coldest week			Week 3		
	Gas consumption (kWh)		Mean external temperature	Gas consumption (kWh)		Mean external temperature	Gas consumption (kWh)		Mean external temperature
	Median (kWh)	IQR for median	Mean ^{0}C	Median	IQR for median	Mean ^{0}C	Median	IQR for median	Mean ^{0}C
Fuel poor	74.76	(60.38, 117.98)	4.0	77.25	(63.49, 125.32)	1.0	63.45	(47.50, 91.94)	*6.6*
Non-fuel poor	70.27	(50.56, 93.27)	3.9	80.12	(55.24, 98.91)	0.9	61.85	(42.01, 82.00)	*6.5*

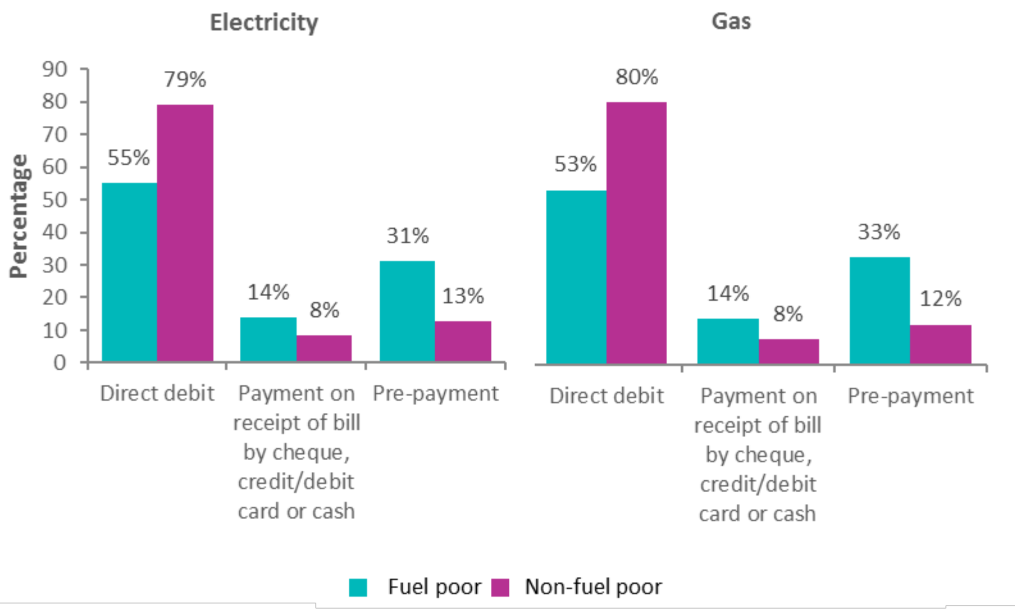
Base: all households with detailed gas consumption data (n = 104: n = 16 for fuel poor, n = 88 for non-fuel poor); all households with Met office data (n = 505, external temperatures: n = 137 for fuel poor, n = 168 for non-fuel poor).

4.4 Method of Payment and Household Energy Costs

Across all households surveyed in EFUS 2017, over three quarters (76%) reported they paid for their electricity by direct debit, 15% by pre-payment, and 9% by standard credit. Similarly, for gas, 77% of all householders paid by direct debit, 14% by pre-payment, and 9% by standard credit.

Households in fuel poverty were more likely to pay for their electricity and gas by pre-payment (31% and 33% respectively), compared with the non-fuel poor (13% and 12% respectively) (Figure 4.3).

Figure 4.3: Electricity and gas method of payment, by fuel poverty



Base: all households (n = 2,604 for electricity, n = 2,184 for gas), Interview 1.

An annual total household gas and electricity bill was calculated by taking valid gas and electricity meter point data for all households (electricity consumption in kWh/year) and combining with reported gas and electricity tariff comparison rate (TCR) values (p/kWh). Fuel poor households were found to have significantly higher median annual gas and electricity costs (£1,080), when compared with non-fuel poor households (£860). The results for total gas and electricity costs by fuel poverty status are summarised in Table 4.3.

Table 4.3: Median annual gas and electricity energy costs, by fuel poverty

		Gas and electricity cost (£/year)	
	Sample size	Median	IQR for median
Fuel poor	*106*	1,080	(770; 1,500)
Non-fuel poor	*322*	860	(610; 1,220)

Base: all households with meter point and TCR data, and gas or electricity as the main fuel (n = 428).

Total household energy costs were calculated in the same way as above, using information on estimated gas and electricity costs, and were combined with reported information on the costs of other fuels used for heating, hot water, and cooking[9]. The median total energy costs showed a significant difference between fuel poor and non-fuel poor households, where the annual costs were calculated as £1,190/year and £910/year respectively. These results are in line with other results obtained in EFUS 2017, where the fuel poor were more likely to spend more than the non-fuel poor to meet their energy needs. Furthermore, as the depth of fuel poverty increased, so did the total household energy cost; fuel poor households with a low fuel poverty gap had median total energy costs of £980/year, compared with £1,330/year for those fuel poor households with a high fuel poverty gap.

4.5 Affordability and Trade Offs

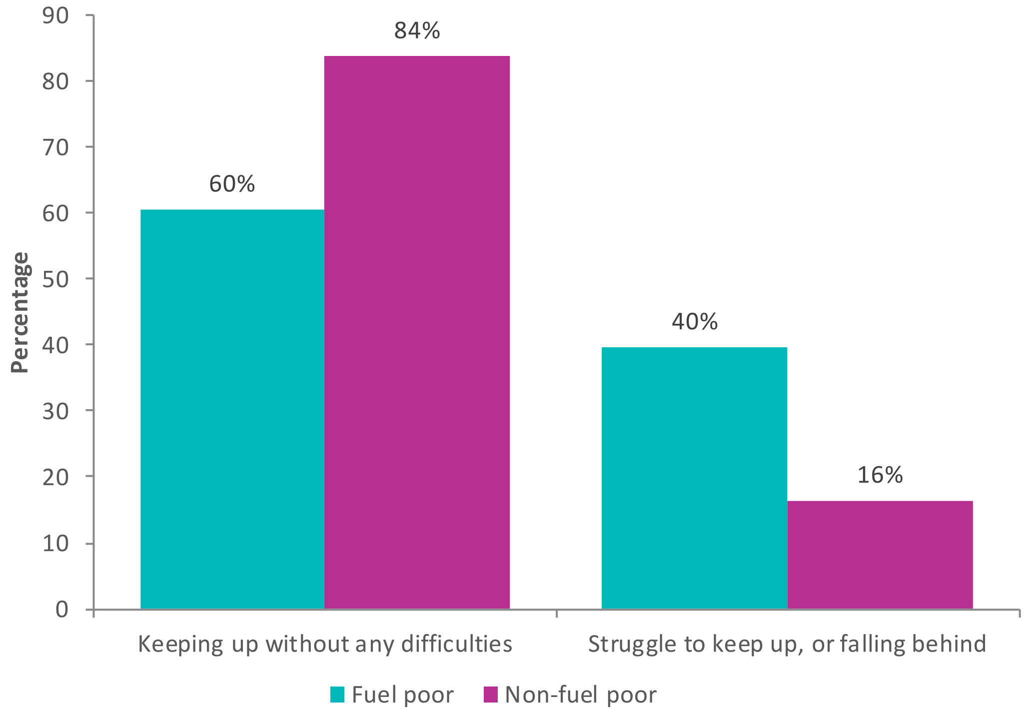
Households were asked about how they had been keeping up with their energy bills and if any concessions had been made to be able to afford them. Fuel poor households may be expected to report greater difficulties in paying their energy bills, an assumption that was supported by EFUS 2017; fuel poor households were more likely (40%) to report struggling to keep up with their energy bills compared with the non-fuel poor (16%) (Figure 4.4).

Interestingly there were no significant differences in the reported prevalence of struggling to keep up with bills between low income households with low energy costs and low-income households with high energy costs and there were no significant differences between households at varying depths of fuel poverty. Additionally, similar results were obtained for other typically low-income households, where lone parents with dependent children, larger households, and households with children present were all more likely to report struggling to

[9] Excluding households with communal/district heating systems, or households who have not reported their other fuel costs.

keep up with their energy bills. These results reiterate the key role income plays in driving this trend[10].

Figure 4.4: Affordability of energy bills, by fuel poverty

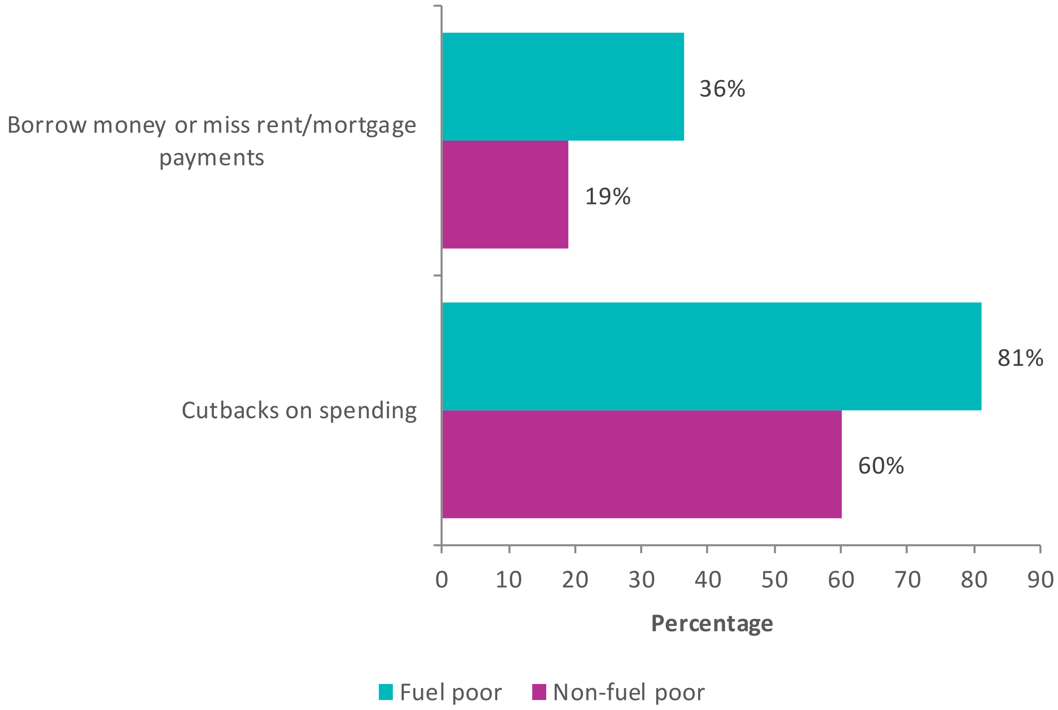


Base: all households (n = 1,026 keeping up without difficulties, n = 286 struggle to keep up or falling behind), Interview 2.

Further questions were asked of those households that reported to struggle to keep up with their energy bills on any cutbacks made in order to afford those bills. Fuel poor households were found to be more likely (at the 95% level) to cut back on spending (81%) or borrow money or miss a rent/mortgage payment (36%) than non-fuel poor households (60% and 19% respectively) (Figure 4.5).

[10] Accompanying annex tables can be found in Tables_5.xls of the Household Energy Consumption and Affordability Report.

Figure 4.5: Changes to heating or spending habits, by fuel poverty



Base: all households struggling to keep up with energy bills (n = 282).

4.6 Metered and Modelled Energy Use

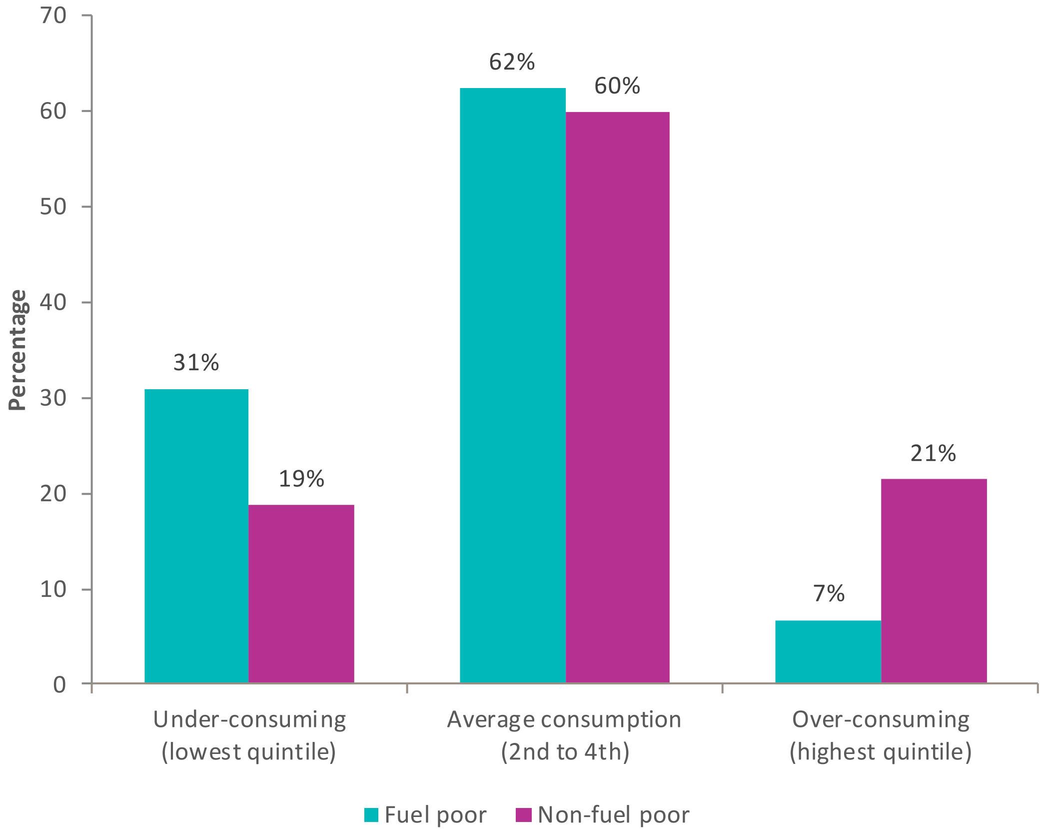
This section explores the differences in metered and modelled energy use, as calculated using the BREDEM energy model and compares fuel poor and non-fuel poor households. Modelled energy use is the theoretical amount of energy consumed by a household to provide an adequate level of warmth, hot water, lighting, appliance use, and cooking use. Analysis was carried out on households that had not undergone any dwelling or occupancy changes since the EHS, to allow for better comparisons of energy consumption. Additionally, only households using mains gas or electricity for their space and water heating requirements were included in the sub-sample.

For the purposes of reporting, households have been classified as under-consumers if relative to other households the percentage difference between actual and modelled energy consumption was in the lowest quintile, and as over-consumers if the percentage difference was in the highest quintile. As shown in Figure 4.6, fuel poor households were more likely (31%) to under-consume than non-fuel poor households (19%), and conversely, the fuel poor were less likely to over-consume than the non-fuel poor (7% and 21% respectively).

The results can be explained using information about the fuel poor in terms of heating hours, internal temperatures, thermal comfort, and affordability of energy bills. Households in fuel poverty were more likely to live in less energy efficient dwellings compared with the non-fuel poor (fuel poor: F or G 15%, D 26%; non-fuel poor: F or G 3%, D 12%). In addition, households in fuel poverty were more likely to be in during the day (57%) compared with households not in fuel poverty (42%). Despite this there were no significant differences in internal temperatures in the living room or main bedroom (Chapter 5), nor were there any significant differences in heating hours (Chapter 6).

Therefore, based on these results it is not surprising that as mentioned in section 4.5, households in fuel poverty were more likely to report struggling to keep up with their energy bills (40%) compared with households not in fuel poverty (16%). Furthermore, households in fuel poverty were more likely to report being uncomfortably cold in the living room and main bedroom[11] (see Chapter 5). A combination of high modelled energy consumption figures for the fuel poor, caused by less energy efficient dwellings and increased daytime occupancy hours[12], without the corresponding change in heating behaviours as measured in EFUS, contribute to the high level of under-consumption observed for fuel poor households.

Figure 4.6: Proportion of households under- and over-consuming compared with modelled energy consumption



Base: all households in the meter point data sub-sample, eligible for comparison with BREDEM modelled consumption (n = 1,181).

[11] Main bedroom was significant at the 95% level.
[12] The BREDEM calculation assumes that, for weekdays, heating hours are 16 hours for someone in during the day, and 9 hours (split into two heating periods) for remaining households.

5. Thermal Comfort, Ventilation, Damp and Mould

This section of the report examines householders' behaviours and responses to heating, ventilation, and thermal comfort, and explores associated problems, such as summer overheating, underheating, and damp and mould, all within the context of fuel poverty status[13].

5.1 Measured Internal Temperature

Analysis of measured temperatures is of crucial importance in terms of household energy policy and public health, as extremes in internal temperatures (both high and low) can have severe consequences, especially to vulnerable households. Although fuel poor households had, on average, lower internal temperatures in the living room and main bedroom than non-fuel poor households throughout the year, differences were not statistically significant during the 2018/2019 winter period. Fuel poor households had an average internal temperature in the living room of 18.3°C compared with 18.7°C for households not in fuel poverty.

Additional analysis was carried out looking at the hottest and coldest weeks of the temperature monitoring period, however in these cases there were no significantly different results between households in fuel poverty and those not in fuel poverty. This could indicate that during extreme warm temperatures, both fuel poor and non-fuel poor households face similar issues relating to being able to properly cool their homes. However, while the temperature analysis did not find any significant differences, the gas consumption analysis in section 4.3 suggests the fuel poor are not able to respond to cold periods in the same way as the non-fuel poor by heating their homes more.

Section 4.3.4 in the Thermal Comfort, Ventilation, Damp and Mould Report further explores the measured incidence of overheating, which is of particular interest in households comprising older people who are most likely to be at risk of harm from overheating.

5.2 Winter Thermal Comfort

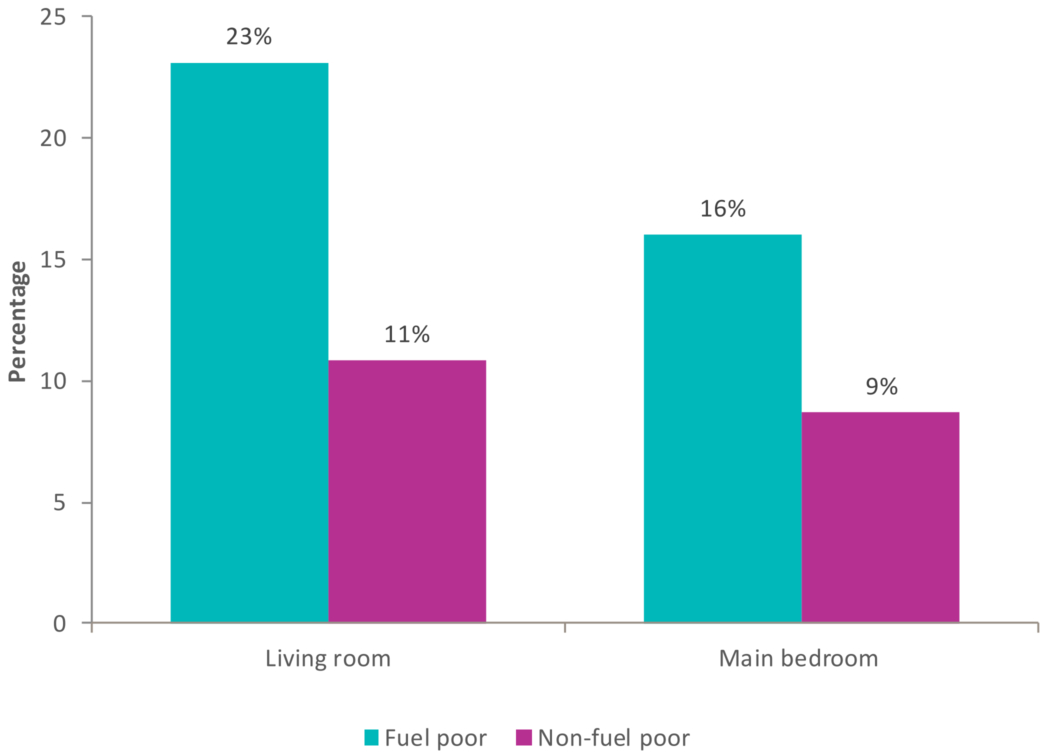
Fuel poverty is often associated with an inability to afford the fuel required to heat the home to a comfortable level and therefore increases the risk of feeling uncomfortably cold. This section will compare winter thermal comfort between fuel poor and non-fuel poor households, exploring how often householders feel uncomfortably cold in their homes and any reasons for this thermal discomfort.

[13] Annex tables containing the underlying data for this section can be found in Tables_5.xls.

Fuel poor householders were over twice as likely to feel uncomfortably cold[14] in their living rooms (23%) than non-fuel poor householders (11%) (Figure 5.1)

Fuel poor households (at the 95% level) were more likely to feel uncomfortably cold in the main bedroom (16%) than households not in fuel poverty (9%)

Figure 5.1: Feeling uncomfortably cold in the living room and main bedroom by fuel poverty



Base: all households (n = 1,146 living room, n = 1, 183 bedroom), Interview 2.

The most common reason given for the living room feeling uncomfortably cold in both fuel poor and non-fuel poor households was due to draughts. There were no differences seen between fuel poor households by the banded fuel poverty gap with regards to their winter thermal comfort.

Further analysis was carried out exploring additional household and dwelling characteristics and their interactions with fuel poverty and winter thermal comfort. The key findings were:

- Fuel poor households without children were markedly more likely to report feeling uncomfortably cold in the living room (23%) than non-fuel poor households without children (9%). Significant differences were not observed between fuel poor households with children and non-fuel poor households with children

[14] Householders reported on whether they felt uncomfortably cold 'often' or 'always' in the living room and main bedroom.

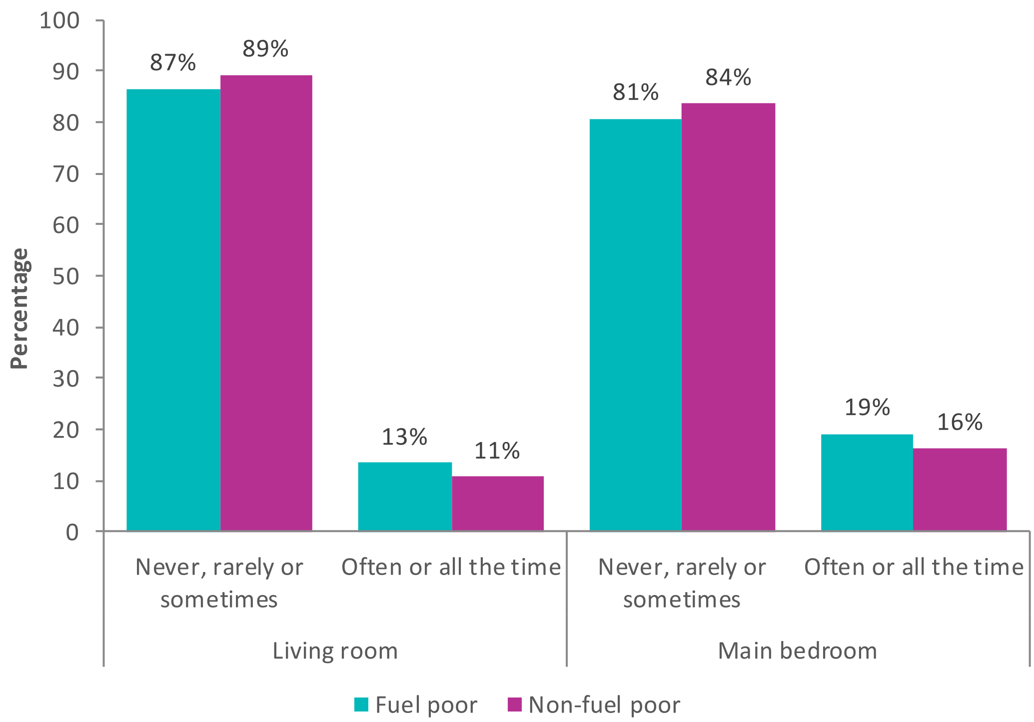
- Fuel poor households with no one in employment were more likely to feel uncomfortably cold in the living room (30%) when compared with the non-fuel poor (11%) with no one in employment. However, there was no difference reported for households with at least one person in employment split by fuel poverty status. Indicative results (at the 95% level) for the main bedroom showed similar trends. This could suggest a connection between employment status and lower incomes, and the likelihood of being at home for longer throughout the day, and an increased exposure to, and thus perception of, cold temperatures in the home

Householders were also asked if they felt uncomfortably cold in any other rooms in the dwelling, with 52% of fuel poor households reporting this, compared with 41% of non-fuel poor households (significant at the 95% level).

5.3 Summer Thermal Comfort

Typically, much attention is given to the winter thermal conditions of the fuel poor, however it is also of interest to understand if the fuel poor are more likely to encounter difficulties with overheating in the summer. The reported incidence of overheating in both living rooms and main bedrooms was examined by fuel poverty status (Figure 5.2) but no statistically significant results were evident.

Figure 5.2: Overheating in the living room and main bedroom by fuel poverty



Base: all households (n = 2,529 living room, n = 2,504 bedroom), Interview 1.

While there was no significant difference between fuel poor and non-fuel poor households in terms of the frequency of overheating in the living room, there was an interesting decreasing trend in reported overheating as the depth of fuel poverty increased. At the 95% level, households with a high banded fuel poverty gap were less likely (9%) to report feeling uncomfortably warm often or all the time in the living room, compared with households with a low banded fuel poverty gap (19%). No similar results were reported for the main bedroom.

To explore these results further, summer thermal comfort was analysed by fuel poverty status and a number of dwelling and household characteristics, where the overall findings were similar to reported winter thermal comfort in section 5.2.

Fuel poor households where no one was in employment (at the 95% level) were more likely (17%) to report feeling thermal discomfort in the living room compared with non-fuel poor households (10%)

There was however no similar significant result reported for households where at least one person was in employment. This could indicate a link between employment status and an increased likelihood of being in the dwelling for longer, and the increased risk of experiencing thermal discomfort in the home.

5.4 Ventilation, Damp, and Mould

This section examines the ventilation behaviours of householders and the potential reasons for the lack of ventilation in living rooms and/or bedrooms, window opening behaviours, and the use of extractor fans in the bathroom. The key findings are:

Fuel poverty status had no effect on the frequency of both indoor clothes drying and the opening of windows while drying clothes

The results for other ventilation behaviours such as use of extractor fans indicate that the behaviours exhibited by fuel poor and non-fuel poor households were more similar than they were different

One of the concerns associated with fuel poverty is that it may lead to internal dwelling conditions detrimental to the health and wellbeing of occupants; these can be the cold conditions themselves, but also the increased presence of damp and mould within an inadequately heated property.

Householders were asked about the presence of damp and mould, which was found to be significantly higher in fuel poor households (42%) than non-fuel poor households (25%)

Further analysis was carried out to see if there was any link to clothes drying behaviours. Fuel poor households that dried their clothes indoors were more likely (34%) to report issues of damp and mould than non-fuel poor households (22%) that did the same. It should be noted, however, that although fuel poor households were more likely to report problems with damp and mould, there was no statistically significant link between fuel poverty status and the reported incidence of any health problems made worse by damp and/or mould. Nonetheless, 37% of non-fuel poor and 42% of fuel poor households reported health conditions being made worse by the presence of damp and/or mould.

Fuel poor households were more likely (at the 95% level) to report the presence of dampness and mould in their homes, irrespective of whether or not someone had a long-term illness or disability.

Fuel poor households with someone with a long-term illness or disability were more likely (43%) to report issues of damp and mould compared with non-fuel poor households with a long-term illness or disability (27%)

Similarly, fuel poor households with no one with a long-term illness or disability were more likely (40%) to report the presence of damp and mould compared with their non-fuel poor counterparts (25%)

The difference in the reported incidence of damp and mould between fuel poor and non-fuel poor households is a complex issue and difficult to attribute to one cause, rather it is likely related to a number of factors, including household energy consumption, heating patterns, housing quality and occupant behaviours.

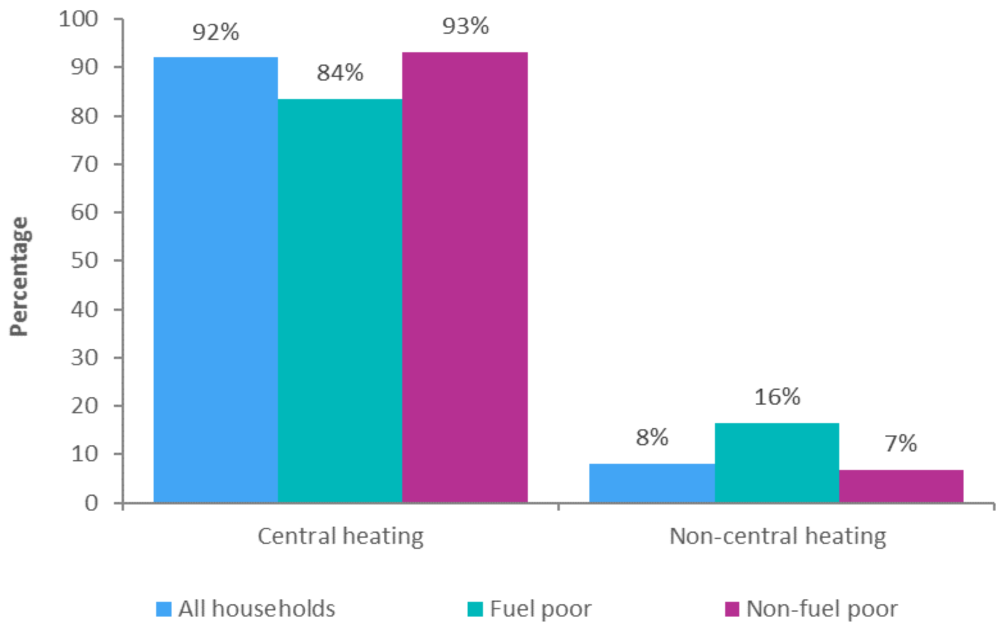
6. Heating Patterns and Occupancy

Using information collected from all three interview surveys, this section comparatively explores the main heating systems and fuel types used in fuel poor and non-fuel poor households and will investigate typical occupancy patterns, space heating behaviours, and hot water systems and usage, giving an overview of occupant behaviour within the home[15].

6.1 Main Heating Systems

By definition, fuel poor households have high energy costs – i.e. their modelled fuel costs are above the median of all households. As a result, fuel poor households are likely to be overrepresented among households with higher cost heating systems. Two heating groups have been produced for further analysis; ‘central heating’ includes central heating, communal heating, and heat pump systems, while ‘non-central heating’ includes storage heaters and room heaters. Across all households central heating was most common, with 92% reporting using a main central heating system to heat their home in the winter. When fuel poor and non-fuel poor households were compared, however, non-central heating systems were much more common among fuel poor households. The main heating system was reported as a non-central heating system in 16% of fuel poor households, compared with 7% for non-fuel poor households (Figure 6.1).

Figure 6.1 : Heating system by fuel poverty

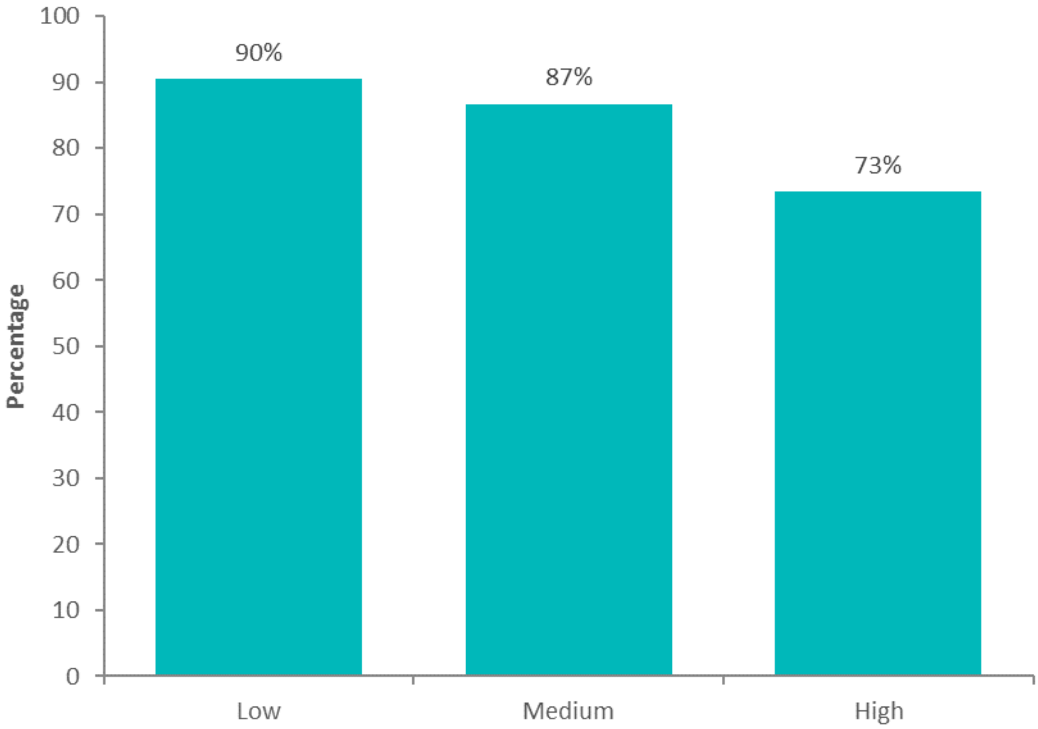


Base: all households (n = 1,186), Interview 2.

[15] Annex tables containing the underlying data for this section can be found in Tables_6.xls.

Furthermore, at the 95% level, 90% of households with a low banded fuel poverty gap had a central heating system compared with 73% of households with a high banded fuel poverty gap (Figure 6.2).

Figure 6.2 : Proportion of households with central heating by fuel poverty gap



Base: all households (n = 215), Interview 2.

Additionally, the fuel type of the main heating system was analysed by fuel poverty status.

Fuel poor households (77%) were less likely than non-fuel poor households (84%) to use mains gas as the fuel for their main heating system

Correspondingly, the fuel poor were more likely (15%) to use electricity as the fuel for the main heating system than the non-fuel poor (6%)

Households with a high banded fuel poverty gap were less likely (60%) to use mains gas than households with low or medium banded fuel poverty gaps (88% and 83% respectively)

Given the increased likelihood of fuel poor households having a non-central heating system, the results of main heating fuel type are perhaps unsurprising. These combined results also indicate fuel poor households were more likely to have a more expensive main heating system than the non-fuel poor.

6.2 Heating Controls

As households with central heating systems were the most prevalent, further analysis was carried out on the mechanisms used to control these heating systems, comparing fuel poor and non-fuel poor households.

At Interview 2, the most common methods of controlling the timing of the heating systems in centrally heated homes were timers (46%) and manual control using thermostat (34%)[16], followed by heating controlled by a switch on the boiler (14%). When comparing fuel poor and non-fuel poor households, there were no significant differences in terms of the different ways in which the central heating system timing was controlled. Furthermore, there were no significant differences when split by fuel poverty for methods of controlling the temperature, including the use of thermostatic radiator valves (TRVs) and room thermostats, nor were there any significant differences in the variability of thermostat settings (whether the thermostat was generally left at the same level or if it varied throughout the day).

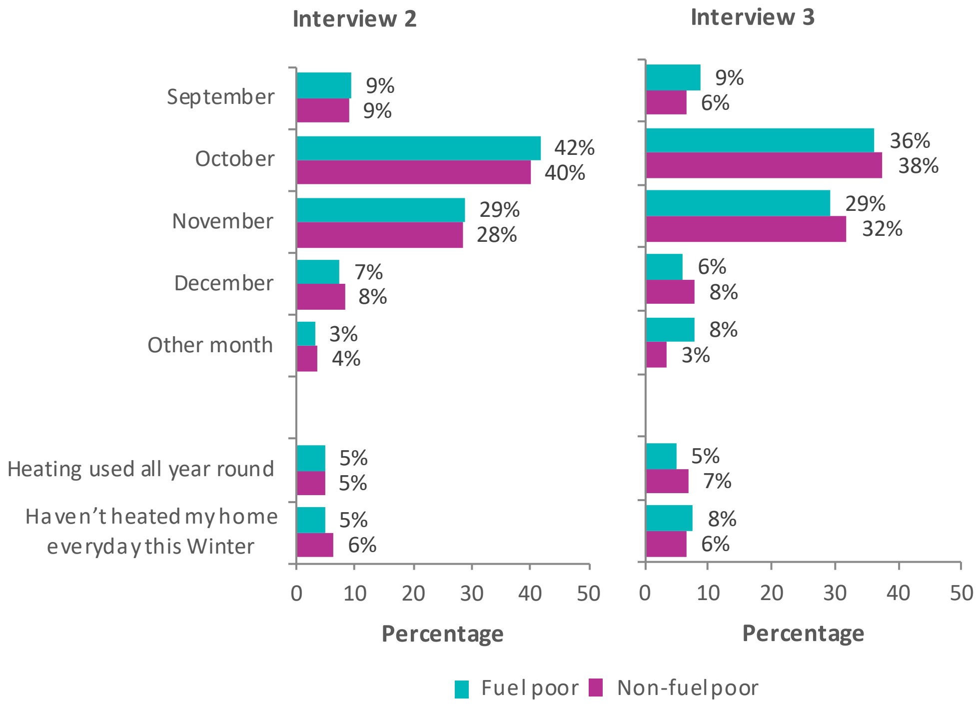
All of these results indicate that while there are clear differences between the type of main heating systems and the main fuels used between fuel poor and non-fuel poor households, differences in the way central heating systems are controlled are less distinct between the two groups. Whilst there were no clear differences in the control of their central heating, differences were noted regarding space heating use and occupancy patterns (see section 6.4).

6.3 Main Heating Season and Heating Patterns

Over a third of fuel poor (42%) and non-fuel poor (40%) households reported that daily heating started in October of the 2017/2018 heating season (Figure 6.3). Similarly, 36% of fuel poor households and 38% of non-fuel poor households reported starting daily heating in October in the 2018/2019 heating season. Again, fuel poverty status seemed to have a negligible effect on when households reported stopping their daily heating; 38% of households in fuel poverty stopped daily heating in April, as did 38% of non-fuel poor households. The mean length of the 2018/2019 heating season was 5.6 months for fuel poor households, and 5.7 months for non-fuel poor households.

[16] Additional information obtained at Interview 3 suggests some of this latter group did have an underlying timer control for their boiler; 24% of households controlled their heating manually using a thermostat and had no timer for the boiler and a further 10% of households had a timer to control their boiler but used the thermostat to manually 'fine-tune' when their heating came on and off. For further information, see section 3.2.1 in the Heating Patterns & Occupancy Report.

Figure 6.3: Month that daily heating started



Base: all households (n = 1, 303), Interview 2; (n = 1,161) Interview 3.

When total heating hours were examined for all households, fuel poor households reported weekday and weekend median heating times of 7hrs:00mins and 7hrs:30mins respectively, while non-fuel poor households reported a weekday median heating time of 7hrs:15mins and a weekend median heating time of 8hrs:00mins (Table 6.1). These hours were not significantly different, nor was there any difference in the number of fuel poor or non-fuel poor households heating their home on a non-regular basis.

Table 6.1: Median number of daily hours of heating for fuel poor and non-fuel poor

	Sample size	Median (hrs:mins)	IQR for median (LQ, UQ)
Weekday day			
Fuel poor	*222*	7:00	(5:00, 10:00)
Non-fuel poor	*831*	7:15	(5:00, 10:00)
Weekend day			
Fuel poor	*211*	7:30	(5:30, 11:00)
Non-fuel poor	*798*	8:00	(6:00, 12:30)

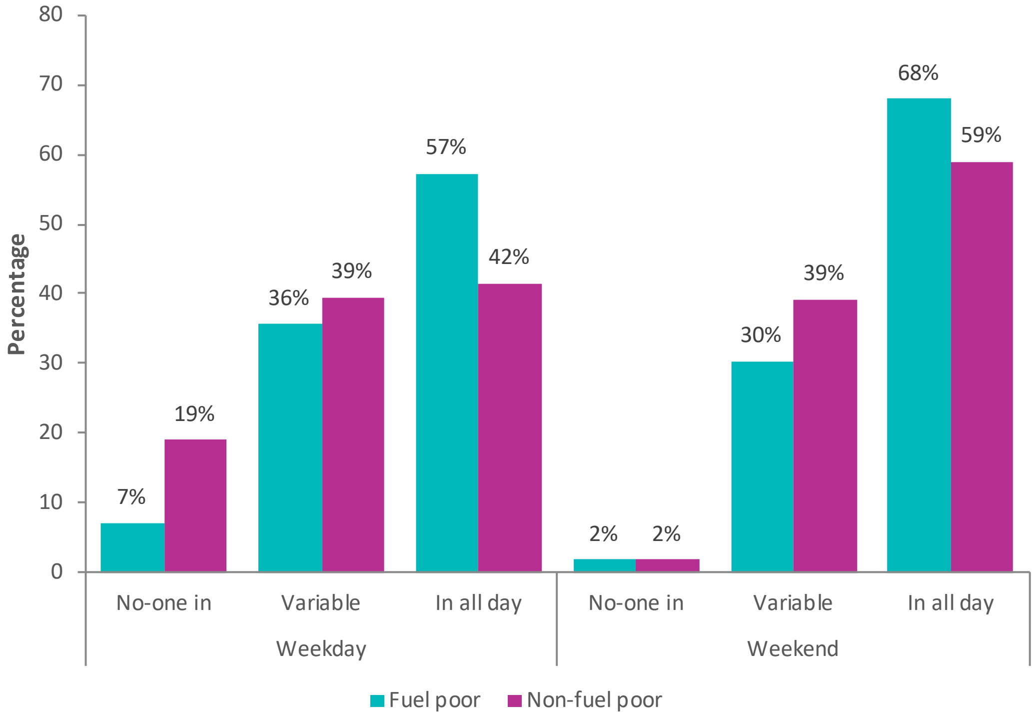
Base: all households, Interview 3.

With regards to the extent of main heating, fuel poor households were no more likely to have any unheated habitable rooms than non-fuel poor households (29% and 26% respectively), however there was some evidence (at the 95% level) to suggest that in households where the main heating was usually turned off in at least one habitable room, fuel poor households were more likely (8%) to use an alternative heater compared with non-fuel poor households (3%). There was no indication of any link between the use of supplementary heating and fuel poverty status.

6.4 Occupancy and Space Heating Patterns

Fuel poor households were more likely (57%) to have someone at home throughout the day during the week, compared with non-fuel poor households (42%) (Figure 6.4). However, the same analysis for weekends did not result in significant differences in occupancy patterns between the two groups.

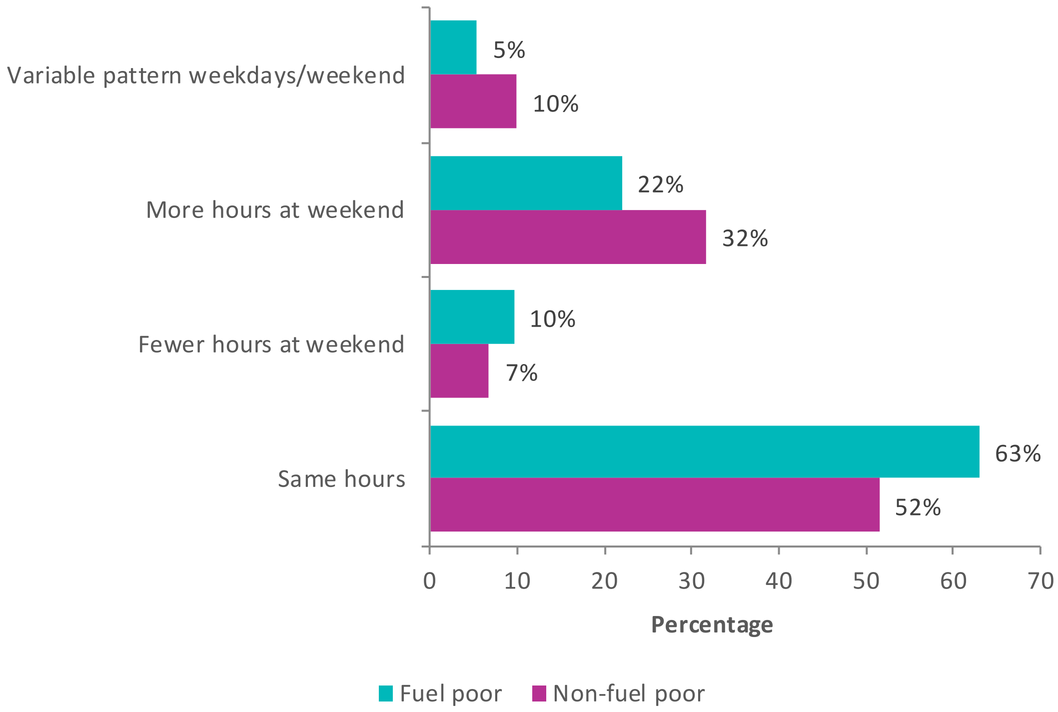
Figure 6.4: Daytime occupancy weekdays and weekend days by fuel poverty



Base: all households (n = 1,176 weekdays, n = 1,178 weekends), Interview 3.

Additional analysis was carried out exploring if weekday daytime occupancy was different to weekend daytime occupancy; at the 95% level, fuel poor households were less likely (37%) to report a difference, while almost half (48%) of non-fuel poor households reported different hours of daytime occupancy between weekdays and weekends. These results are broken down further in Figure 6.5. Fuel poor households were also less likely (14%) to report changes in their daytime occupancy across different weekdays, compared with non-fuel poor households (23%).

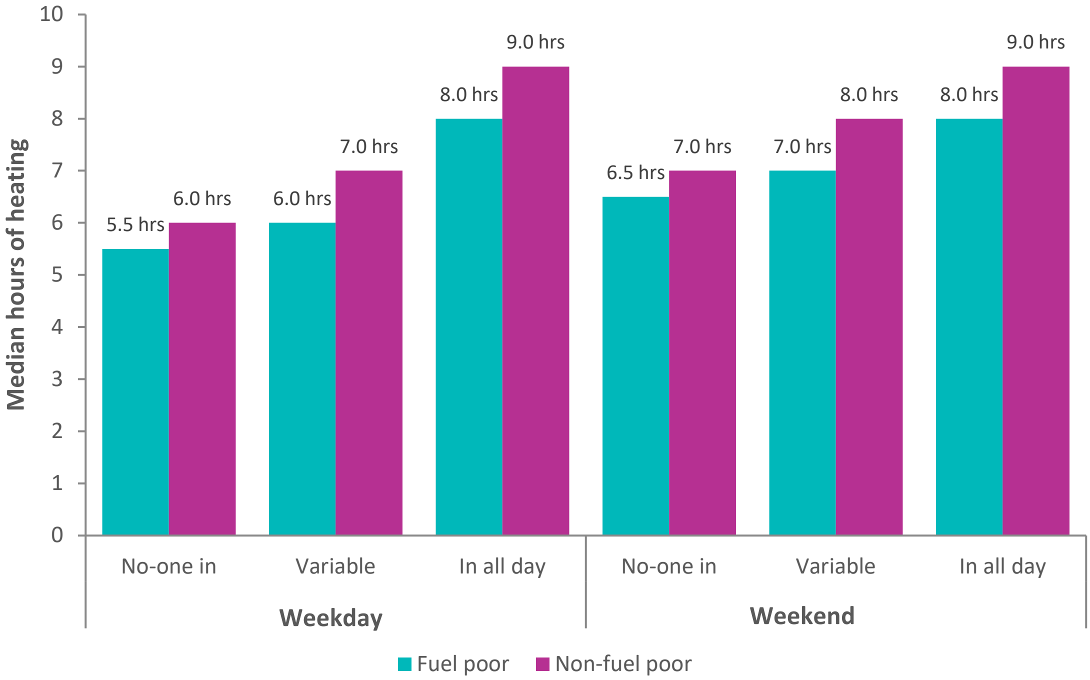
Figure 6.5: Daytime occupancy comparisons for weekdays and weekend days by fuel poverty



Base: all households (n = 1,176), Interview 3.

Reported weekday and weekend occupancy patterns were explored further by space heating behaviours, split by fuel poverty status. Fuel poor households with someone in the home all weekday reported heating their homes for fewer median hours (8hrs:00mins) than the non-fuel poor (9hrs:00mins) (Figure 6.6). Fuel poor households with variable weekday daytime occupancy patterns reported a median heating time of 6hrs:00mins, while the corresponding non-fuel poor households reported a median heating time of 7hrs:00mins, however these differences were not statistically significant. The equivalent analysis for space heating patterns and weekend occupancy were also not significant between fuel poor and non-fuel poor households.

Figure 6.6: Median heating hours on weekdays and weekends by fuel poverty



Base: all households (Weekday: n = 131, No-one in, n = 392, Variable, n = 525, In all day, Weekend: n = 120 No-one in, n = 377, Variable, n = 507 In all day), Interview 3.

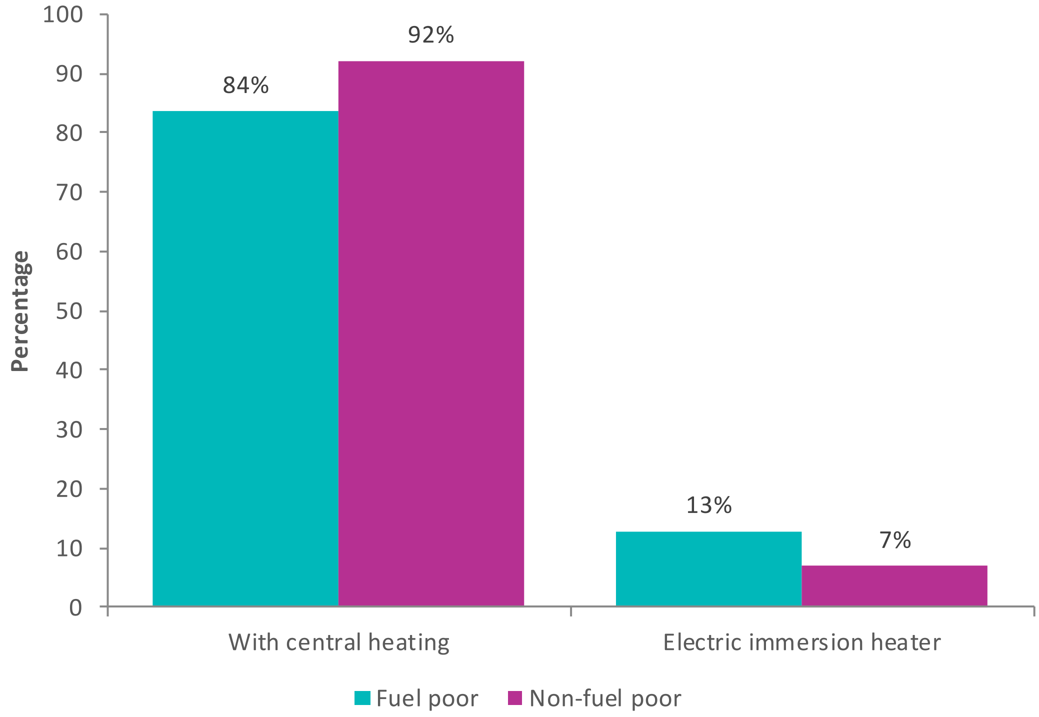
6.5 Hot Water Systems and Usage

The main type of water heating system present across all dwellings surveyed in the EFUS survey was via the central (space) heating boiler, 91% of households reported using this type of system, followed by electric immersion heaters being used in 8% of households, with either a dedicated boiler or instantaneous heaters used in the remainder of households[17].

When exploring this analysis further by fuel poverty status, it was found that the fuel poor were less likely (84%) to heat their water with a central heating system, compared with the non-fuel poor (92%), and the fuel poor were almost twice as likely (13%) to heat their water with an electric immersion heater than the non-fuel poor (7%) (Figure 6.7).

[17] This is based on the data as reported in the EHS, with no updates at the time of EFUS

Figure 6.7: Water heating by electric immersion or with central heating systems by fuel poor households



Base: all households (n = 2,912), Interview 1.

Electric immersion heater use was analysed by investigating several different splits; summer and winter immersion heater use in centrally heated and non-centrally heated households was further split by fuel poverty status. Fuel poverty was not a significant factor in the prevalence of electric immersion heater use in the summer, in either centrally heated households or non-centrally heated households. However, at the 95% level, there was an indication of fuel poor centrally-heated households using the immersion heater more than non-fuel poor households, with 21% of fuel poor households reporting using the immersion heater every day/almost every day compared with 6% of non-fuel poor households. Fuel poverty status was not a significant factor for electric immersion heater use in non-centrally heated homes during winter.

Among all households surveyed, 81% reported having both a shower and a bath, 12% reported only having a shower, and 7% reported only having a bath. When split by fuel poverty status, there was a significant difference at the 95% level in households where there was only a bath present, where the fuel poor were over twice as likely (13%) to have a bath, compared with the non-fuel poor (6%). However, there were no significant differences reported between fuel poor and non-fuel poor households that had both showers and baths or only had showers. Further analysis of households with showers revealed that fuel poor households were more likely (47%) to use an electric shower than non-fuel poor households (35%), and were less likely to use a shower that was pumped from the main hot water system (10% compared with 16%).

The median number of daily baths and showers taken per person in fuel poor and non-fuel poor households is presented in Table 6.2[18].

Table 6.2: Median showers/baths per person by ownership of baths and showers by fuel poverty

	Number of baths taken daily per person			Number of showers taken daily per person		
	Sample size	Median	IQR for median	*Sample size*	Median	IQR for median
Fuel poor						
Bath/s only (no shower present)	*38*	0.29	(0.19,0.71)			
Bath/s and shower/s present	*190*	0.06	(0,0.18)	*180*	0.67	(0.5,1)
Shower/s present (no bath present)				*30*	1.00	(0.5,1)
Non-fuel poor						
Bath/s only (no shower present)	*75*	0.43	(0.18,0.86)			
Bath/s and shower/s present	*831*	0.07	(0,0.21)	*178*	1.00	(0.5,1)
Shower/s present (no bath present)				*153*	1.00	(0.5,1)

Base: all households Interview 2.

In terms of the combined bath and shower daily use per person, at the 95% level, fuel poor households (60%) were more likely than non-fuel poor households (45%) to be taking less than one shower and/or bath per person per day. Households in fuel poverty were also less likely (21%) than those not in fuel poverty (31%) to take a shower and/or bath once per person per day. There was no significant difference in households using the bath/shower more than once a day when analysed by fuel poverty status.

[18] The number of baths and showers taken daily per person was calculated by dividing the number of baths or showers taken daily in the household by the number of occupants.

7. Lights and Appliances

The largest factor contributing to most households' total energy requirement is space heating, but non-heating related energy demands are also of increasing importance. This section of the report will investigate the incidences of different lighting technologies and how this has transformed over time, the ownership and use of appliances, and comparisons of domestic electricity consumption, all within the context of fuel poverty[19].

7.1 Lighting

The presence of several types of lightbulbs in three different areas (living room, kitchen, or bedroom) of the dwelling were investigated, comparing fuel poor and non-fuel poor households.

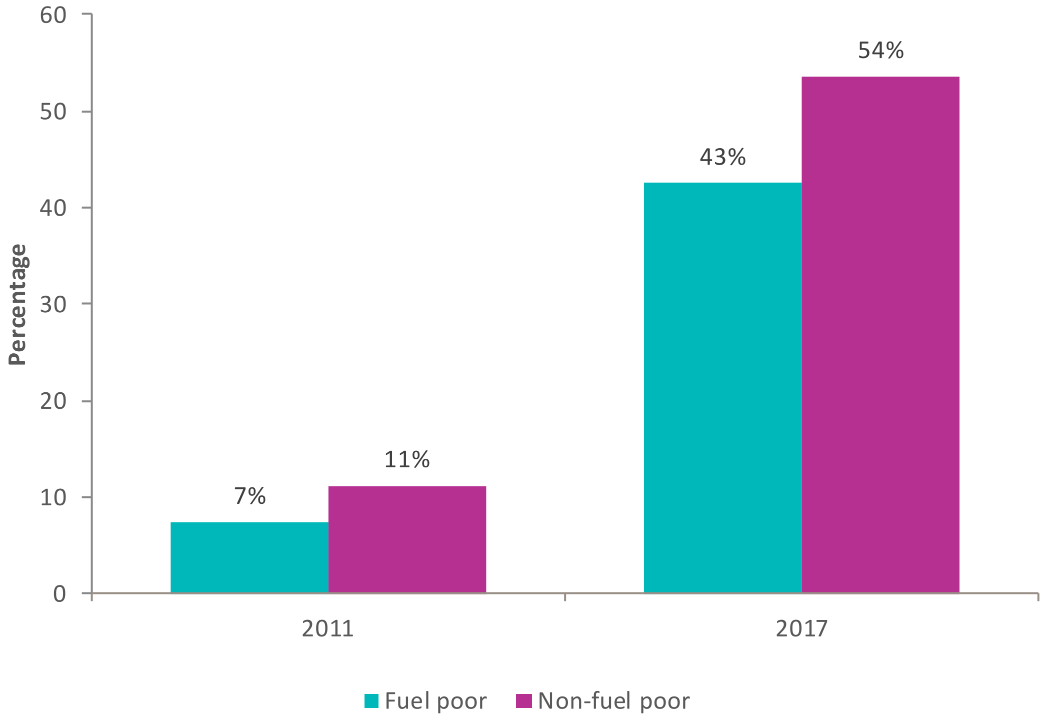
Households not in fuel poverty (54%) were significantly more likely to own low energy LED bulbs than those in fuel poverty (43%) (Figure 7.1)

In 2011, 7% of fuel poor households and 11% of non-fuel poor households owned LED lightbulbs, but this difference was not found to be statistically significant

These results indicate that, while the prevalence of these types of lightbulbs has increased in both groups, the increase is disproportionately towards the non-fuel poor and fuel poor households may be paying more to light their homes than non-fuel poor households.

[19] Annex tables containing the underlying data for this section can be found in Tables_7.xls.

Figure 7.1: Household ownership of LED lightbulbs by fuel poverty status, 2011 and 2017



Base: all households (n = 2,395 EFUS 2011, n = 2,597 EFUS 2017), Interview 1.

7.2 Appliance Ownership and Use

Ownership and use of household appliances, including cold appliances, dishwashers, cooking appliances, entertainment devices, and other leisure equipment were analysed by fuel poverty status.

It was found that households not in fuel poverty were significantly more likely (46%) to own dishwashers than households in fuel poverty (32%)

Results from EFUS 2011 found that there was also a significant difference, although only at the 95% level, in the ownership of dishwashers between fuel poor (31%) and non-fuel poor (39%) households

These results show that ownership of dishwashers amongst fuel poor households has broadly stayed the same, while increasing for non-fuel poor households.

In 2011, there was a significant difference in TV ownership between fuel poor (96%) and non-fuel poor (98%) households. However, there was no such similar result in 2017, where 96% of both fuel poor and non-fuel poor households reported ownership of a TV

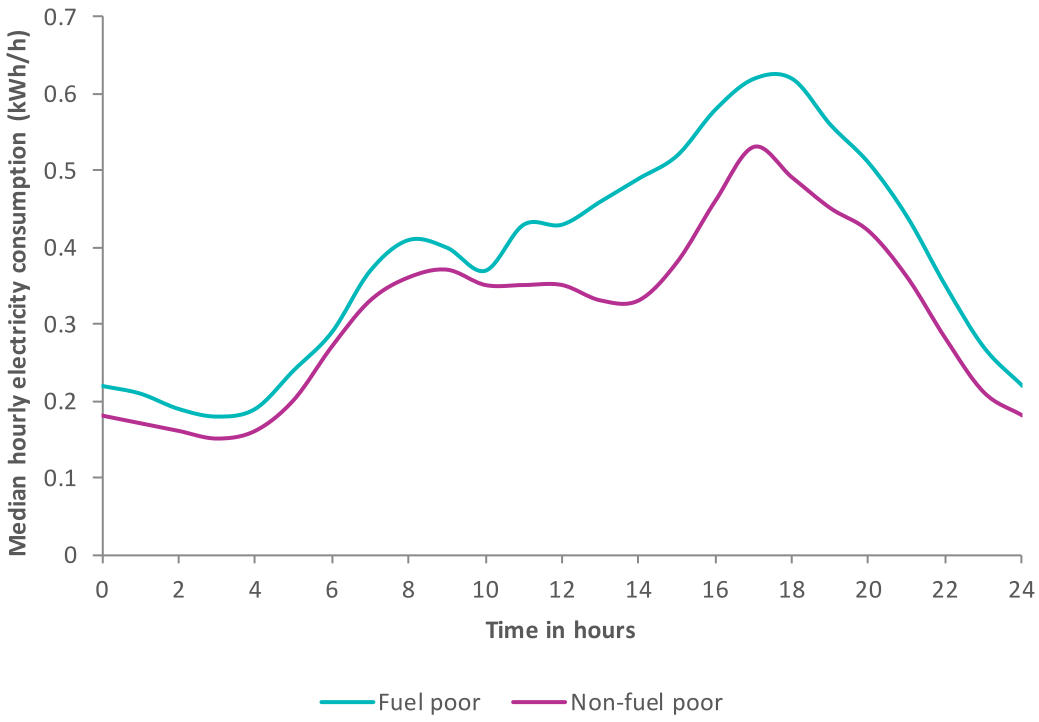
Fuel poor households were more likely (46%) to own a games console than non-fuel poor households (35%). This result could be reflective of the demographics of the fuel poor, as this group is likely to be made up of lone parent households and households with dependent children

7.3 Detailed Electricity Consumption

Detailed electricity consumption data was collected for 395 households (81 fuel poor, 314 non-fuel poor) where electricity was not the main heating fuel, allowing for the calculation of daily and hourly averages.

As reported in section 4.2, for households not using electricity as their main fuel, the fuel poor were found to use significantly more electricity than households not in fuel poverty, based on bivariate analysis [20], therefore the differences in their median daily profiles are of interest, as shown in Figure 7.2. While both fuel poor and non-fuel poor households broadly followed the same trends in consumption, the degree of consumption between the two groups was notably different. Both fuel poor and non-fuel poor households started off with similar consumption patterns, but by the early afternoon the fuel poor showed greater levels of consumption than the non-fuel poor, reaching a higher peak in consumption in the early evening. Both groups showed a similar decrease in consumption following this evening peak.

Figure 7.2: Median profile of mean hourly electricity consumption, 1st May 2018 to 30th April 2019, by fuel poverty status; fuel poor and non-fuel poor

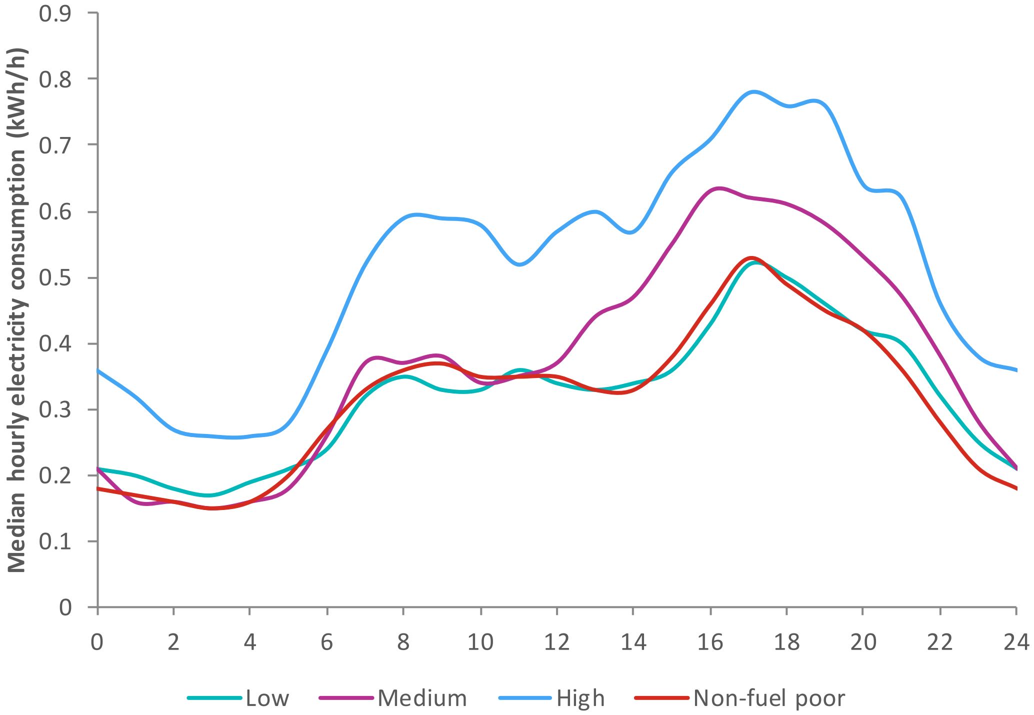


Base: all households (n = 395) with electricity consumption data, main fuel not electric.

[20] However, multi-variate analysis showed that the fuel poverty status of households was not found to be an important factor in explaining variability in electricity consumption, when considering other variables within the final model.

Figure 7.3 shows the median daily consumption profile for fuel poor households, split out using the low, medium, and high banded fuel poverty gap indicator, and non-fuel poor households. The profiles followed a similar daily pattern, with peaks in consumption at the beginning and end of the day, however there were increasing levels of consumption seen as the banded fuel poverty gap increased from low to high. Interestingly the consumption pattern of those fuel poor households with a low banded fuel poverty gap almost mirrors that of households not in fuel poverty.

Figure 7.3: Median profile of mean hourly electricity consumption, 1st May 2018 to 30th April 2019, by fuel poverty status; banded fuel poverty gap indicator and non-fuel poor

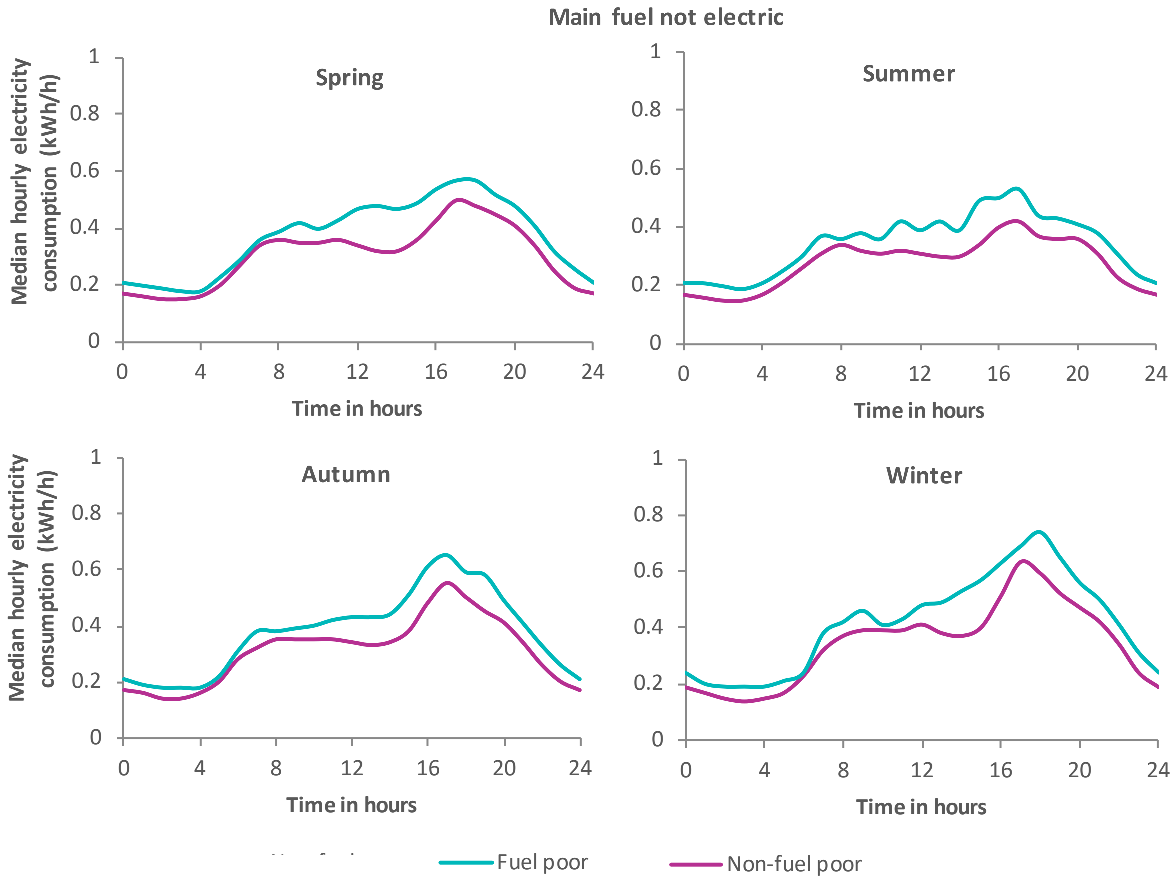


Base: all households (n = 395) with electricity consumption data, main fuel not electric.

Note: Medium and High fuel poverty gap indicator profiles based on small sample sizes (n = 24 Medium, n = 24 High), indicative only.

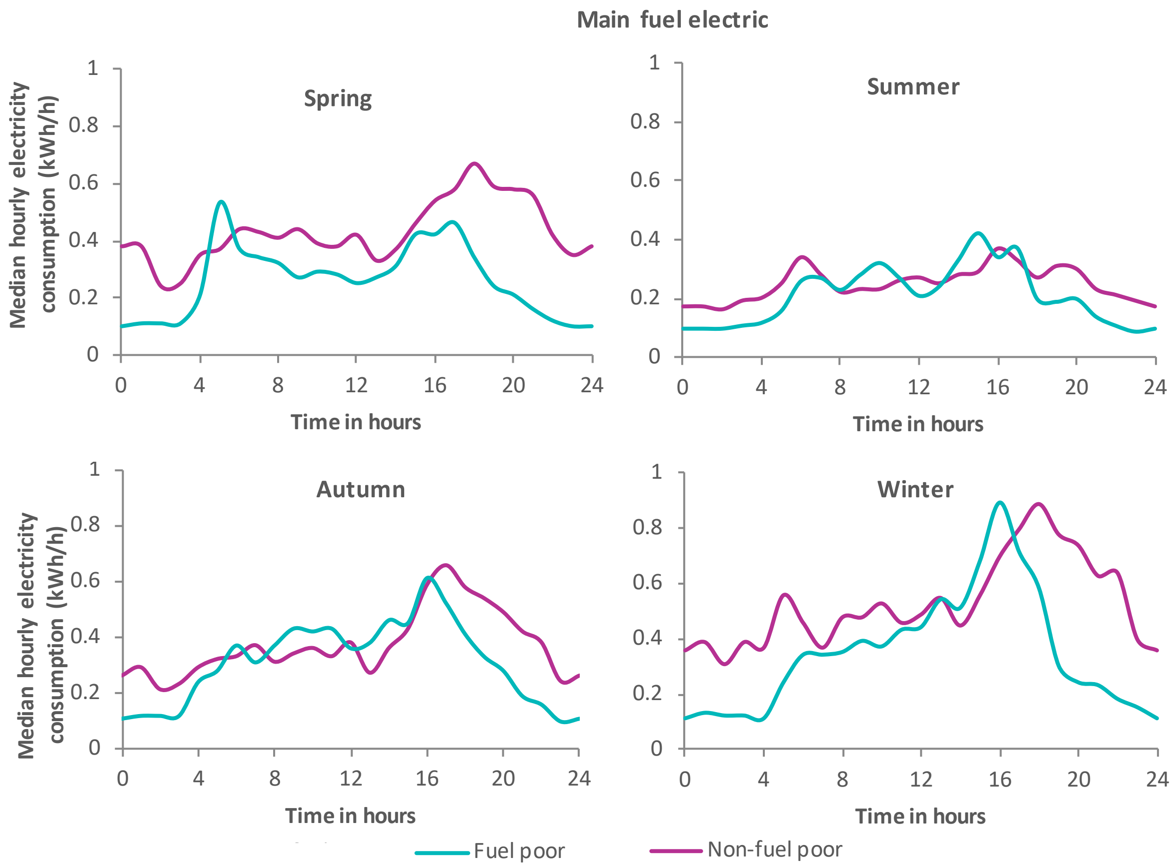
The consumption profiles split out by season and fuel poverty status for households where the main heating fuel is not electricity (Figure 7.4) showed the same overall patterns, with an increase in consumption between 04:00 and 08:00, followed by a levelling off in the early afternoon, before increasing to a peak at around 18:00 followed by a steady decrease throughout the rest of the evening. There was a clear difference in the extent of consumption, with winter consumption being the highest and summer consumption being the lowest. The most noticeable difference in the profiles was that the fuel poor consumed more electricity, a trend that was sustained throughout the year. Figure 7.5 shows a similar set of consumption profiles across the seasons, this time looking at households where electricity was the main heating fuel.

Figure 7.4: Median profiles of mean hourly electricity consumption for the four seasons, 1st May 2018 to 30th April 2019, by fuel poverty status



Base: all households with electricity consumption data for each season, main fuel not electric (n = 359-392).

Figure 7.5: Median profiles of mean hourly electricity consumption for the four the seasons, 1st May 2018 to 30th April 2019, for households with electric main heating fuel, by fuel poverty status



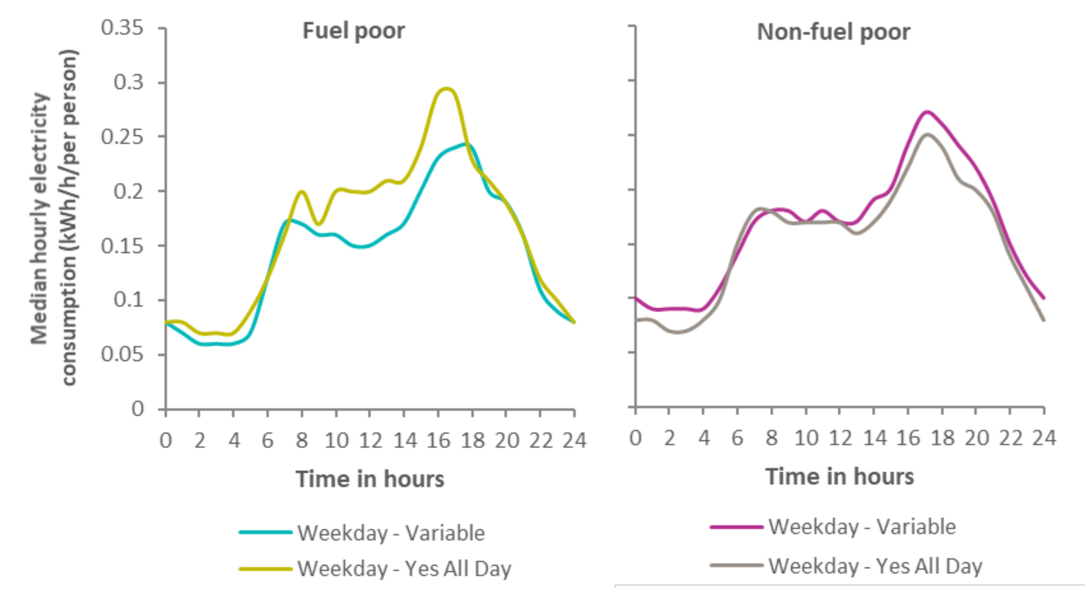
Base: all households with electricity consumption data for each season, main fuel electric (n = 38-41).

Note: Fuel poor and Non-fuel poor profiles based on small sample sizes (n = 12-13 Fuel poor, n = 25-28 Non-fuel poor), indicative only.

The following analysis was carried out on normalised electricity consumption data. The data was normalised by dividing the electricity consumption by the number of people in the household to give a per capita consumption figure. This was done in order to explore patterns in electricity consumption, while accounting for the influence of household size.

Figure 7.6 shows the normalised median consumption profiles for fuel poor and non-fuel poor households, by weekday occupancy. Both fuel poor and non-fuel poor households followed the same typical consumption patterns, where there was a small peak in consumption in the morning, followed by a larger peak in the early evening. While there was little difference in the consumption profiles of non-fuel poor households based on their weekday occupancy, fuel poor households with someone in all day on weekdays consumed more electricity than those fuel poor households where there was variable weekday occupancy, however these results should be interpreted as indicative only due to small samples in the fuel poor sub-set.

Figure 7.6: Median profiles of mean hourly electricity consumption, 1st May 2018 to 30th April 2019, for fuel poor and non-fuel poor households, by weekday occupancy, normalised to household size



Base: all households (fuel poor n = 56, non-fuel poor n = 224) with electricity consumption data, main fuel not electric, Interview 3.

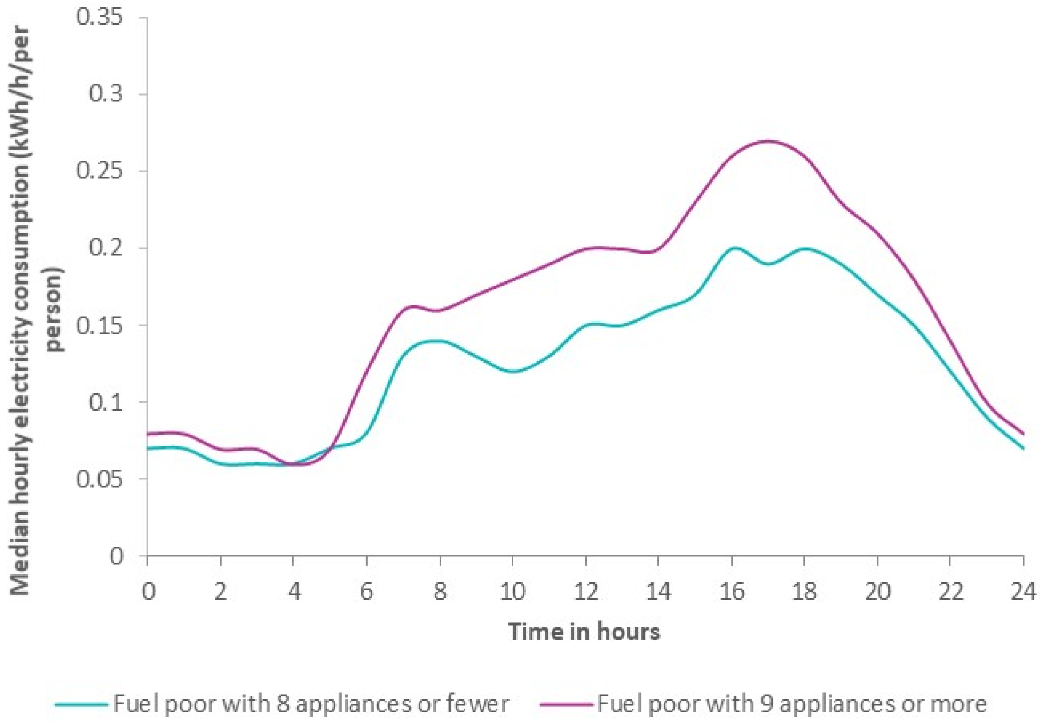
Note: Fuel poor weekday variable occupancy profile based on small sample sizes (n = 24), indicative only.

Note: Profiles for households with no one in between 9am and 5pm on weekdays have not been included due to small sample sizes.

Note: Based on occupancy, household size, and main heating fuel variables from Interview 3.

Figure 7.7 shows how the normalised median consumption profile for fuel poor households, by number of appliances. Unsurprisingly, households with more appliances consumed more electricity, however the profiles generally followed similar patterns.

Figure 7.7: Median profiles of mean hourly electricity consumption, 1st May 2018 to 30th April 2019, for fuel poor households by number of appliances, normalised to household size

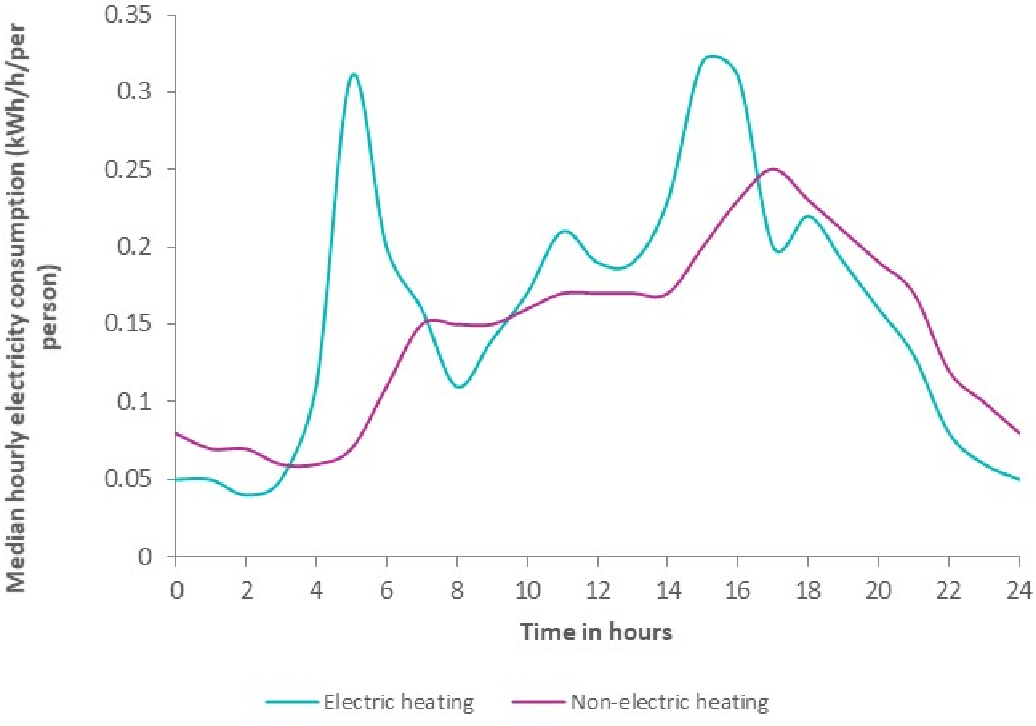


Base: all households in fuel poverty (n = 81) with electricity consumption data, main fuel not electric.

As the fuel poor were more likely to use electricity as their main heating fuel (see section 6.1), it is of interest to see how the consumption profiles of this group compare between those households that do not use electricity as their main heating fuel. It should be noted that the sample size was limited, and therefore these results should be treated as indicative only.

Figure 7.8 shows the normalised median consumption profiles throughout the whole year for fuel poor households, with and without electricity as the main heating fuel. The consumption profiles show a clear difference in use between households that use electricity as their main heating fuel and those that do not, which is not unexpected. There is a large peak in the early morning around 06:00 for households using electricity as the main heating fuel, followed by a gradual increase in consumption to a second peak in the afternoon that extends into the evening. Conversely, there is no morning peak in consumption for households not using electricity as their main heating fuel, instead a small increase in consumption is observed the morning around 08:00, which plateaued throughout the afternoon before, reaching a peak in the evening.

Figure 7.8: Median profile of mean hourly electricity consumption for fuel poor households, 1st May 2018 to 30th April 2019, with and without electricity as the main heating fuel, normalised to household size



Base: households in fuel poverty (n = 13, electric heating, n = 81 non-electric heating).

Note: Electric heating profile based on small sample size (n = 13), indicative only.

8. Summary of Findings and Conclusions

The 'Fuel Poverty' report brings together the comparative findings for fuel poor and non-fuel poor households from all other EFUS 2017 reports. Findings from all three household interview surveys, meter point data, and detailed temperature and consumption data have returned valuable information on household energy consumption, main heating systems and main heating fuels, thermal comfort and ventilation behaviours, all within the context of fuel poverty status.

The main conclusions from each report can be summarised as:

8.1 Household Energy Consumption and Affordability

Energy consumption

Meter point data for 2017 was used to calculate the average annual household gas and electricity consumption.

The median gas consumption figures for fuel poor and non-fuel poor households were 13,300 kWh/year and 12,200 kWh/year respectively.

The median electricity consumption figures for households where electricity was not the main heating fuel was 3,400 kWh/year for fuel poor households and 2,900 kWh/year for non-fuel poor households, and 6,800 kWh/year for fuel poor households and 7,100 kWh/year for non-fuel poor households where electricity was the main heating fuel.

Results from linear regression of gas consumption indicate that dwelling characteristics were better at explaining the variability in gas consumption for non-fuel poor households than fuel poor households.

Detailed gas consumption data was used to compare consumption patterns across the year and during periods of extremely cold weather.

Comparing the average daily gas consumption for the coldest week in winter 2018/19 and the week prior to this, fuel poor households were less likely (44%) to increase their gas consumption by 5% or more compared with non-fuel poor households (70%).

Under- and over-consumption

Households were defined as 'under-consuming' if relative to other households the percentage difference in modelled and actual energy consumption was in the lowest quintile (using less energy than modelled), and households were classified as 'over-consuming' if the percentage difference was in the highest quintile (using more energy than modelled).

Fuel poor households were more likely (31%) to under-consume than non-fuel poor households (19%). Fuel poor households were also less likely (7%) to over-consume than the non-fuel poor households (21%).

Affordability and trade-offs

Householder's responses to questions on the affordability of energy bills and average tariff comparison rates (TCR) were collected in the interview surveys. The TCR was combined with median metered consumption figures to provide estimated annual household gas and electricity costs.

Households in fuel poverty were more likely to pay for their electricity and gas by pre-payment (31% and 33% respectively), compared with the non-fuel poor (13% and 12% respectively).

Fuel poor households were found to have significantly higher median annual gas and electricity costs (£1,080), when compared with non-fuel poor households (£860).

Fuel poor households were more likely (40%) to report struggling to keep up with their energy bills compared with the non-fuel poor (16%).

Fuel poor households were more likely to cut back on spending (81%) or borrow money or miss a rent/mortgage payment (36%) than non-fuel poor households (60% and 19% respectively).

8.2 Thermal Comfort, Ventilation, Damp and Mould

Winter thermal comfort

The prevalence of thermal discomfort over winter was asked of householders, as well as the perceived causes of any thermal discomfort.

While fuel poor households had, on average, slightly lower internal household temperatures throughout the whole year, there was no significant difference from non-fuel poor households.

Fuel poor householders were around twice as likely to feel uncomfortably cold in their living rooms (23%) than non-fuel poor householders (11%).

Fuel poor households were more likely to feel uncomfortably cold in the main bedroom (16%) than households not in fuel poverty (9%).

Fuel poor households without children were markedly more likely to report feeling uncomfortably cold in the living room (23%) than other households without children (9%).

Fuel poor households with no one in employment were more likely to feel uncomfortably cold in the living room (30%) when compared with the non-fuel poor (11%) with no one in employment.

Summer thermal comfort

No significant differences were found when analysing the incidence of reported summer overheating by fuel poverty status.

Ventilation, damp, and mould

Fuel poor households were significantly more likely (42%) to report issues of damp and mould than non-fuel poor households (25%).

Fuel poor households with someone with a long-term illness or disability were more likely (43%) to report issues of damp and mould compared with non-fuel poor households where someone had a long-term illness or disability (27%).

Similarly, fuel poor households with no one with a long-term illness or disability were also more likely (40%) to report the presence of damp and mould compared with their non-fuel poor counterparts (25%).

8.3 Heating Patterns and Occupancy

Main heating systems

The main heating system was reported as a non-central heating system in 16% of fuel poor households, compared with only 7% for non-fuel poor households.

As the fuel poverty gap increased from low to high, the prevalence of central heating being the main heating system decreased (90% and 73% respectively).

Fuel poor households were less likely (77%) than non-fuel poor households (84%) to use mains gas as the fuel for their main heating system.

Fuel poor households were more likely (15%) to use electricity as the fuel for the main heating system than the non-fuel poor (6%).

Households with a high banded fuel poverty gap were less likely (60%) to use mains gas than households with low or medium banded fuel poverty gaps (88% and 83% respectively).

Main heating season

Over a third of fuel poor (42%) and non-fuel poor (40%) households reported daily heating started in October of the 2017/2018 heating season.

Similarly, 36% of fuel poor households and 37% of non-fuel poor households reported starting daily heating in October in the 2018/2019 heating season.

Occupancy and space heating

Fuel poor households were less likely (37%) to report a difference in daytime occupancy between weekdays and weekends compared with the non-fuel poor (48%).

Fuel poor households were less likely (23%) to report changes in their daytime occupancy across different weekdays, compared with non-fuel poor households (14%).

Hot water systems and usage

The fuel poor were almost twice as likely (13%) to heat their water with an electric immersion heater than the non-fuel poor (7%).

For combined daily bath and shower use per person, fuel poor households were more likely (60%) than non-fuel poor households (45%) to be taking less than one shower and/or bath per person per day.

Households in fuel poverty were less likely (21%) than those not in fuel poverty (31%) to take a shower and/or bath once day.

8.4 Lights and Appliances

Lighting

Households not in fuel poverty were significantly more likely (54%) to own low energy LED bulbs than those in fuel poverty (43%).

Results from EFUS 2011 found there was no significant difference in LED lightbulb ownership between the fuel poor and the non-fuel poor. In 2011, 7% of fuel poor households and 11% of non-fuel poor households owned LED lightbulbs.

Appliance ownership and use

Households not in fuel poverty were significantly more likely (46%) to own dishwashers than households in fuel poverty (32%).

Results from EFUS 2011 found that there was also a significant difference in the ownership of dishwashers between fuel poor (31%) and non-fuel poor (39%) households.

In 2011, there was a significant, albeit minor, difference in TV ownership between fuel poor (96%) and non-fuel poor (98%) households. There was no such similar result in 2017, where 96% of both fuel poor and non-fuel poor households reported ownership of a TV.

Fuel poor households were more likely (46%) to own a games console than non-fuel poor households (35%).

8.5 Fuel poverty churn

Exploratory analysis was conducted at the sample level to investigate the movement of households in and out of fuel poverty (known as fuel poverty churn).

The fuel poverty status of households at Interview 1 and Interview 3 was updated based on reported changes since the EHS, including: changes to occupants, changes to household income after housing costs, and dwelling improvements. Due to these changes, the fuel poverty status was calculated based on whether the household from the EFUS would be in fuel poverty at the time of their EHS survey. The key findings are summarised as follows:

In total, 3% of households at Interview 3 moved into fuel poverty since the EHS, and 4% of households moved out of fuel poverty since the EHS, based on the changes to households and dwelling improvements since the EHS.

Dwelling improvements resulting in a change in modelled energy performance were stated in 12% of households. Improvements were enough to change the EPC band in 27% of these households with improvements, and the most frequently reported improvements were new boilers, loft insulation, and floor insulation.

Changes to household income since the EHS caused incomes to increase in 16% of households and decrease in 27% of households. Most cases with an income change were associated with the HRP and partner income (78%), with remaining cases changed due to additional adult incomes (13%), or a combination of both (9%).

Increases in HRP and partner income were due to increased salaries (38%), change in job (19%), working more hours (17%) and increased income from benefits (15%). Decreases in HRP and partner income were reported to be due to a decrease in employment income in 57% of cases. Other reasons included an overestimation of the EHS income (20%) and decreased income from benefits (17%).

Occupant changes caused equivalised incomes to be reduced in 59% of households; and increased in 41% of households; and caused equivalised fuel costs to be reduced in 35% of households and increased in 39% of households.

At the sample level, 9% of cases with dwelling improvements moved out of fuel poverty between the EHS and Interview 3. In addition, 13% of cases with increased income moved out of fuel poverty; and 8% of cases with decreased income moved into fuel poverty.

Glossary

Term	Description
Age of dwelling:	This is the date of construction of the oldest part of the dwelling. Recorded by surveyors in the EHS physical survey.
Age of HRP:	The Household Reference Person (HRP) is the person in whose name the dwelling is owned or rented or who is otherwise responsible for the accommodation. In the case of joint owners and tenants, the person with the highest income is taken as the HRP. Where incomes are equal, the older is taken as the HRP. This procedure increases the likelihood that the HRP better characterises the household's social and economic position. The age of the HRP is derived from:
	variables obtained from the EHS Interview survey for households that had not changed since the earlier EHS interview.
	householder responses to questions 45-50 in EFUS Interview 1 and questions 41-45 in EFUS Interview 3 for new households.
Alternative heating:	Heating system present in a room (or rooms) used as an alternative to the main heating system.
After housing costs equivalised income – weighted quintiles:	This is calculated based on the fuel poverty income (from 2015 & 2016 fuel poverty datasets) and updated to account for any changes to income at Interview 1 and Interview 3 EFUS questionnaires. Validation of income based on reasons why household income had changed for the Interview 3 questionnaire provided increased confidence and reliability of the income.
Boiler type:	Derived from the EHS data.
Children Present:	Anyone in the household who is 16 years old or younger at the time of the EFUS interview. This is derived from;
	variables obtained from the EHS Interview survey for households that had not changed since the earlier EHS interview.
	householder responses to questions 45-50 in Interview 1 and questions 41-45 in Interview 3 in the EFUS questionnaires for new households
Daytime Occupancy	Derived from the EFUS survey. A household has been classified as being 'in during a weekday' if they indicated being generally in the house on weekdays during the winter, for both the morning and afternoon periods. A household is classified as 'not in during the day' if they responded as not being in for both the

	morning and the afternoon periods. Households who were in for either the morning or afternoon period were coded as ‘Variable’ occupancy.
Dwelling insulation:	The number of insulation measures (0 to 3) where positive responses for ‘fully double glazed’, ‘insulated walls’ and having loft insulation greater than 200mm count as insulation measures. EFUS Interview 1 and interview 3 questionnaires asked respondents about new insulation measures installed since the EHS survey. New windows installed since the EHS survey are excluded from the analysis as it cannot be assumed that this resulted in the dwelling being fully double glazed.
Dwelling type:	Classification of dwelling on the basis of the surveyors’ inspections during the EHS physical survey.
Employment status of the household:	Derived from W1_q56 of EFUS Interview 1, and the modelling assumes responses are for all adults in the household (HRP, partner and any other additional adults in employment). ‘Don’t know’ responses were coded as having no employment. Households either have at least one person employed, or all adults are unemployed.
Energy Performance Certificate (EPC) band:	Energy Performance Certificate band, also sometimes known as the Energy efficiency rating (EER) band (SAP 2012) of the dwelling. Bands from A to G that are used in the Energy Performance Certificate. ‘A’ is the most efficient and ‘G’ is the least efficient. Derived from the SAP 2012 methodology used for the 2016 EHS. SAP2012 was re-modelled for dwellings which have had improvements between the EHS and EFUS Interviews 1 and 3.
Fuel poverty (LIHC) status:	Based on the ‘Low Income High Cost’ (LIHC) definition, a household is considered to be fuel poor if: they have required fuel costs that are above average (the national median level); were they to spend that amount, they would be left with a residual income below the official poverty line. Each household’s fuel poverty status has been updated using EFUS data on household changes, incomes and modelled fuel costs due to dwelling improvements.
Fuel poverty gap:	The difference in pounds between the required energy costs for each fuel poor household and the nearest fuel poverty threshold.
Fuel type of main heating system:	As recorded by surveyors in the EHS physical survey. Grouped into ‘mains gas’, ‘electricity’ and ‘other’, which includes bottled gas, bulk gas, solid fuels, oil and community schemes. The data was updated at Interview 2 and Interview 3 if a household reported using a different main heating system.

	Assumptions for households reporting having central heating but did not answer about fuel type: - Set to mains gas if a mains gas connection was recorded in the EHS - If not on mains gas set to EHS recorded main fuel - If reported not on gas in EFUS Interview 1, then categorised as 'other' gas (e.g. bottled).
Fully double glazed:	Derived from the 'dblglaz4' EHS variable as recorded by surveyors in the physical survey. Fully double glazed is defined as 'entire house double glazed'. Not fully double glazed is anything less than fully double glazed. New windows installed since the EHS survey were excluded from the analysis as it could not be assumed that this resulted in the dwelling being fully doubled glazed.
Heating season:	The months when there is a requirement for the main heating system to provide heat. For the EFUS 2017 survey this is calculated based on householder responses to a question in Interview 2 (what month heating began every day) and a question in Interview 3 (what month heating stopped every day), both asked in relation to Winter 2017/18.
Household size:	Number of persons in the household, banded into 5 groups, derived from the 'hhsizex' variable from the EHS Interview survey. The data was updated following any changes to household composition recorded in EFUS Interview 1 and Interview 3 questionnaires.
Insulated walls:	Derived from the 'wallinsx' variable as measured by surveyors in the EHS physical survey and refers to any insulation for the predominant wall type. The 'solid uninsulated' category includes non-cavity other wall types such as timber, steel or concrete framed. EFUS Interview 1 and Interview 3 questionnaires asked the household about the installation of wall insulation since the EHS survey and the 'wallinsx' variable was updated.
Loft insulation:	Banded variable of 'loftinsx', the level of loft insulation recorded by surveyors in the EHS physical survey. EFUS Interview 1 and Interview 3 questionnaires asked the household about the installation of loft insulation since the EHS survey and the 'loftinsx' variable was updated.
Long-term sickness or disability:	Whether anyone in household has long-term illness or disability that limits their activities. And/or whether anyone in the household is registered disabled. This is self-reported by EHS interview respondents.
Pensioner Present:	Anyone in the household who of state pension using data from the EHS Interview survey. Updates using responses to

	questions 45-50 in Interview 1 and questions 41-47 of Interview 3 EFUS questionnaires.
Region:	Government Office Region that the dwelling is located in. Obtained from the EHS.
Rurality:	Is the dwelling in a rural (village or isolated hamlet) or urban (urban or town or fringe) location. Derived from the 'rumorph' variable in the EHS.
SAP rating:	The energy cost rating as determined by Government's Standard Assessment Procedure (SAP) and is used to monitor the energy efficiency of dwellings. It is an index based on calculated annual space and water heating costs for a standard heating regime and is expressed on a scale of 1 (highly inefficient) to 100 (highly efficient with 100 representing zero energy cost). An updated SAP rating was modelled for dwellings which had improvements between EHS and EFUS Interviews 1 and 3.
Supplementary heating:	Heating systems used in addition to the main heating system to boost internal temperatures.
Tenure:	Derived from the EHS but updated from householder responses in EFUS to q52 in Interview 1 and Q51 of the Interview 3. Cases responding 'don't know' left as the original EHS category. The modelling assumes a response of 'renting' to be a household living in the private rented sector.
Type of (main) heating system:	Derived from the EHS but adjusted for EFUS Interview 2 and Interview 3 responses (question 02). Grouped into central heating or non-central heating categories. Non-central heating includes storage radiators, gas fires, electric heaters, coal/wood/ smokeless fuel fires or stoves and other less common systems.
Under-occupying:	A household is considered to be under-occupying if the dwelling is more than large enough for the number (and type) of occupants living there. For the full definition of under occupancy, see the fuel poverty methodology handbook, which is available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/829010/Fuel_Poverty_Methodology_Handbook_2019.pdf Derived from EHS data and updated based on age and household changes at EFUS Interview 1 and 3.
Useable floor area:	The total usable internal floor area of the dwelling as modelled for the EHS 'floorx', rounded to the nearest square metre. It excludes integral garages, balconies, stores accessed from the

	outside only and the area under partition walls. Grouped into 6 categories.
Water heating system	Derived from EHS data. Categories are: ‘with central heating’, ‘dedicated boiler’, ‘electric immersion heater’, ‘instantaneous’, ‘other’.

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