



Report 10: Household underspend

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Executive summary

The methodology used to produce estimates of fuel poverty in England defines a regime which is considered sufficient to provide adequate energy for heating and other uses in the home. This includes energy for heating, lighting, appliance use and cooking. A household is said to be underspending when its actual fuel expenditure is below that predicted by this theoretical regime.

Based on analysis of the 2011 EFUS, approximately 67% of all households are considered to be underspending to some degree. Around 35% of all households are considered to be underspending by more than 25% of the required fuel bill, and approximately 8% of all households are considered to be underspending by more than 50% of the required fuel bill.

Households that are considered to be underspending have lower mean internal temperatures, and lower achieved temperatures than those that are not. Households exhibiting the highest levels of underspend also report heating for fewer hours per day than households that are not considered to be underspending.

Fuel poor households (as defined using the official Government definition of Low Income High Costs) are more likely to be underspending than non-fuel poor households. Around 80% of those in fuel poverty are considered to be underspending, compared to 65% of households not in fuel poverty.

There is no clear relationship between underspending and income. Low income households are as likely to be considered underspending as high income households. Similarly, the likelihood of underspend is not directly influenced by other household factors including household type, age of household or employment status.

There are, however, clear relationships with the energy efficiency of the property as identified by SAP rating. Those households living in higher energy efficiency properties are less likely to be considered underspending than those in lower energy efficiency properties. Approximately 90% of those living in the least energy efficient properties (below a SAP rating of 30) are considered to be underspending, compared to 47% considered underspending in the most energy efficient properties (SAP >70).

This relationship with energy efficiency is reflected in the fact that households in older properties are more likely to underspend, as are those without gas central heating systems, in poorly insulated properties.

The relationship between energy efficiency and underspend may have significant policy implications. In particular, it highlights that improvements made to poorly performing properties may simply reduce the level of underspend, rather than deliver reductions in consumption.

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1 Introduction

The last large-scale national survey to consider the detailed use of heating systems and other sources of energy use in homes was the 1998 Energy Follow-Up-Survey (EFUS 1998). In that survey, householders were asked detailed questions about the type and usage patterns of the main and secondary heating systems in their homes, the water heating system and usage, dwelling insulation, lighting, indoor temperatures and appliances use. Although now more than ten years old, the information collected from that survey is still among the most up-to-date data on dwelling and household energy use available.

The main aim of the 2011 Energy Follow-Up-Survey (EFUS) was to collect new data on patterns of household and dwelling energy use in order to update the current modelling assumptions about how energy is used in the home. The 2011 EFUS consisted of a follow-up interview survey of a sub-set of households first visited as part of the 2010/2011 English Housing Survey (EHS). Additionally, a sub-sample of these households was also selected to have temperature loggers and electricity consumption monitors installed. A further stage of the EFUS involved the collection of gas and electricity consumption data from meter readings.

This report outlines the results of analysis of these data into the subject of household “underspend”. The fuel poverty methodology, used to produce estimates of fuel poverty in England, defines a regime which is considered sufficient to provide adequate energy for heating and other uses in the home. This includes energy for heating, lighting, appliance use and cooking. A household is said to be underspending when it is not spending sufficiently to meet this regime. This is when the notional fuel bill calculated to be sufficient to provide adequate energy to the household is *higher* than the fuel bill which is actually paid for energy in the home.

The concept of underspend is closely associated with those of fuel poverty and affordable warmth, and was developed in the early 1990s. Underspend was defined in the 1991 EHCS Energy report¹, which used two indicators of fuel poverty. Both indicators were based on the annual total fuel cost required to achieve a set heating regime, adequate lighting, cooking and running costs of typical domestic appliances, in any particular dwelling. The first indicator (percentage of income spent on fuel) required fuel cost to be expressed as a percentage of the household’s annual income. The second (underspend), expressed the households actual fuel expenditure as a percentage of the required fuel costs. Thus underspend illustrates the percentage by which the household’s actual fuel expenditure falls below the required expenditure under fuel poverty assumptions. The second indicator has not been adopted for main stream analysis. It has, however, been suggested that this indicator closely correlates with cold homes and the risk to health², and is also of interest to examine as it is able to provide an insight into how expenditure on energy varies from standard regimes under different household and dwelling characteristics. Furthermore, an examination of underspends relationship with other characteristics can provide an insight into “takeback” of energy

¹ 1991 EHCS Energy Report, HMSO. DOE, 1993.

² 1996 EHCS Energy Report, HMSO. DETR. 2000.

savings following a change to the dwelling (e.g. an energy efficiency improvement) or a change in the household.

The notional fuel bill is taken from the official definition of fuel poverty in England. This definition calculates a fuel bill using the BREDEM energy calculation methodology, combined with tariff information provided by suppliers to DECC. Under this methodology, a specified heating regime is defined, assuming 9 hours of heating on weekdays and 16 at weekends, modified to 16 hours on all days if the household is at home in the week. It is assumed that heating is to 21 degrees in the living room, and 18 degrees in all other areas, modifications also reduce the heated area for households which are underoccupying their homes. BREDEM calculations take account of the energy efficiency of the dwelling fabric and heating system, with energy use also assigned for hot water, lighting, appliance use and cooking.

This report compares the notional fuel bill of households calculated using this methodology, with estimates of actual bills produced from the EFUS data by combining the energy consumption (meter reading) data from the survey with tariff data. The types of household that are considered to be underspending, and the extent of any underspend, are considered, as are temperatures in underspending homes, and dwelling and energy characteristics associated with underspend. The relationships between underspend and the two measures of fuel poverty (10% of income definition and the Hills Review Low Income-High Cost definition) are also presented.

Some key questions related to underspend of interest to those developing energy efficiency policies, and those developing energy modelling methodologies, and which are considered by this analysis are:

- How many households are considered to be underspending?
- How is underspending related to internal and demand temperatures?
- How is underspending related to energy efficiency? What is the relationship with SAP?
- How is underspend related to household characteristics (income, size, age of household etc.)?
- Are households with particular heating systems more likely to underspend? By how much?
- How is underspend related to the presence or absence of energy efficiency measures?
- Are those classified as fuel poor more likely to underspend than other groups?

2 Methodology

In order to calculate household underspend, *actual* fuel expenditure needs to be calculated for the EFUS data, and these divided by the notional fuel bill *requirement* as calculated using the fuel poverty methodology. This produces the fuel cost ratio shown in Equation 1 below. If the fuel cost ratio is below 1 then the household is defined as underspending.

Equation 1: Calculation of the fuel cost ratio

$$\text{Fuel cost ratio} = \frac{\text{Actual fuel expenditure}}{\text{Notional fuel expenditure}}$$

To produce the actual fuel expenditure, the data on gas and electricity consumption collected as part of the EFUS has been combined with data on tariffs. Additional data on the cost of any additional fuels used in addition to gas or electricity has also been included. The metered EFUS dataset (1,345 cases) has been used for this analysis. For full details of the method of collection of the metered fuel consumption sample, please refer to the Metered Fuel Consumption report.

The relationship between internal temperatures and underspending has also been assessed as part of this analysis. Internal temperatures were taken every twenty minutes at three locations within the home: living room, hallway and bedroom. Details on the method of collection and analysis from the temperature loggers can be found in the Mean Household Temperatures and Methodology reports.

The tariff data which have been combined with the consumption data have been produced by combining the information on the location of the suppliers collected directly as part of the EFUS, data on method of payment from the EHS, information on consumption from the metered fuel consumption dataset and energy bill data sheets provided by the UK consumer watchdog “Consumer Futures”.

The Consumer Futures energy bill data sheets are available for each supply region and list the estimated annual bills for each method of payment, for each of the major suppliers. These bills are provided for low, medium and high users. These have been converted into tariffs (p/kWh) by dividing by the assumed consumptions used in the creation of the sheets.

The process of assigning tariffs to each EFUS case proceeded as follows:

- 1) For each case in the sample, the name of the supplier was identified.
- 2) Using the metered consumption data, each case was assigned as a low, medium or high user.
- 3) The supply region of each case was identified using the case postcode.

- 4) Each case was assigned a tariff from the Consumer Focus tariff sheet based on their method of payment (from EHS data), whether they were a low, medium or high user (from the metered consumption data), and their supplier.

Where data on the supplier was missing, or the supplier was not one of the main six suppliers (around 6% of all cases in this dataset), the tariff of the case's home supplier was assigned. This is the supplier which originally supplied energy immediately following the market deregulation in the 1990s.

At the end of this process each case in the metered consumption dataset is assigned a tariff which reflects their supplier, region, method of payment, and whether they are a high or low energy user.

The final stage in the creation of a fuel bill is to multiply the tariff data by the measured consumptions for gas and electricity. Any additional spend on other fuels is estimated by the householder, and recorded in EFUS interview survey. This is combined with this fuel bill information to produce a figure for the total annual fuel cost for the household.

In order to calculate underspend this total fuel *actual* bill is divided by the *required* fuel bill as defined by the fuel poverty methodology. This produces the "fuel spend ratio". These data are calculated using EHS data in the production of annual fuel poverty statistics and are already available as part of the wider EHS dataset.

Comprehensive details of the fuel poverty methodology can be found in the Fuel Poverty Methodology Handbook produced by DECC and BRE³. Some key assumptions within the English fuel poverty definition include:

- Demand temperature of 21 degrees in the main living room (18 degrees elsewhere).
- 9 hours per day heating assumed on weekdays, 16 hours per day on weekends, for households where no-one is at home during the day on weekdays.
- 16 hours per day assumed on all days of the week for all households where someone is at home during the day on weekdays.
- Energy for space and water heating, lighting, appliances and cooking are included.
- Reduced area of the dwelling is heated for those households considered to be under-occupying their homes.

It is important to recognise that the suitability and applicability of the fuel poverty regimes do not form part of the scope of this particular piece of work, and are not commented on to any extent as part of this report. Underspend defined in this way assumes that these regimes are appropriate standards for energy consumption. It is, however, recommended that further analysis considers these issues as recommended by the recent Hills Fuel Poverty Review⁴.

³ Fuel Poverty Methodology Handbook <https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/fuel-poverty-statistics>

⁴ Getting the measure of fuel poverty: Final report of the Hills fuel poverty review. Hills, J (2012)

3 Findings

The findings of the analysis of underspend are presented below. These are based on the consumption data, supplier and tariff information, temperature data and demographic information collected through the EFUS project. These data have been supplemented with data from the English Housing Survey, and from Consumer Futures as described in the methodology section above.

3.1 Underspend

As shown in Table 1 below, approximately 67% of all households are considered to be underspending. Around 33% are considered to be underspending by more than 25% (i.e. their actual bills are more than 25% below their estimated fuel bill requirement) and almost one in ten of all households are considered to be underspending by more than 50%. Also shown is the mean ratio of actual fuel spend to fuel poverty (notional) fuel requirement of each group. The average ratio in the underspending group is 0.72 indicating that, across all of those considered to be underspending, the average level of underspend is approximately 28%. Among all of those not considered to be underspending, the average ratio is 1.5. This indicates that the average level of overspend is 50%. This value is significantly affected by a relatively low number of high consuming households which skew this mean result.

Table 1: Number and percentage of households underspending

Household considered to be underspending?	Sample size	Number of households (000s)	Percentage of all households		Actual fuel spend / notional spend ratio
			(%)	95% C.I.	
Not considered to be underspending	456	7,254	33.1	(30.3, 35.9)	1.50
All considered to be underspending	889	14,640	66.9	(64.1, 69.7)	0.72
All households	1,345	21,894	100.0		0.98
Considered to be <i>underspending by more than 25%</i>	449	7,546	34.5	(29.7, 39.3)	0.58
Considered to be <i>underspending by more than 50%</i>	100	1,727	7.9	(2.1, 13.7)	0.37

Base: All households in the EFUS 2011 meter reading sample (n = 1345).

3.1.1 Temperatures and period of heating in underspending households

In addition to consumption data, the EFUS also collected internal temperature data from households. The temperature data have been used to determine the mean household temperatures and the 'achieved' temperatures in households at the end of a significant period of heating. Further details of these data can be found in the Mean Household Temperatures and Main Heating reports.

It can be seen in Table 2 that mean household temperatures (i.e. 24 hour average temperatures within the dwelling) are lower in those households that are considered to be underspending.

Table 2: Mean internal living room temperatures of underspending households

Household considered to be underspending?	Sample size	Mean Living Room Temperature (all days) (°C)					
		Nov 2011		Dec 2011		Jan 2012	
		Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Not considered to be underspending	182	20.0	(19.7, 20.3)	19.4	(19, 19.7)	19.5	(19.1, 19.7)
All considered to be underspending	363	18.9	(18.6, 19.1)	18.1	(17.8, 18.4)	18.3	(18.0, 18.5)
Considered to be underspending by more than 25%	192	18.8	(18.4, 19.1)	17.9	(17.5, 18.3)	18.2	(17.8, 18.6)
Considered to be underspending by more than 50%	36	18.6	(17.6, 19.5)	17.3	(16.1, 18.3)	17.5	(16.3, 18.6)

Base: All households in both of the EFUS 2011 meter reading and temperature samples (n = 545).

Similarly, the monitored temperatures at the end of the longest heating period (referred to in these reports as the achieved temperatures) are also lower in underspending households. This is shown in Table 3.

Table 3: Achieved temperatures of underspending households

Household considered to be underspending?	Sample size	Mean weekday achieved temperatures (°C)					
		Living room		Hallway		Bedroom	
		Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Not considered to be underspending	182	20.8	(20.4, 21.1)	20.1	(19.7, 20.4)	19.8	(19.3, 20.1)
All considered to be underspending	363	19.8	(19.5, 20)	18.9	(18.6, 19.1)	18.4	(18.1, 18.6)
Considered to be underspending by more than 25%	192	19.5	(19.1, 19.8)	18.6	(18.2, 18.9)	18.0	(17.6, 18.4)
Considered to be underspending by more than 50%	36	18.9	(17.9, 19.8)	18.0	(17.1, 18.8)	17.1	(16.2, 18.0)

Base: All households in both of the EFUS 2011 meter reading and temperature samples (n = 545).

The average length of heating periods (as identified using householder reported data) in underspending households has also been examined. A significant reduction in heating hours is seen for those households with an estimated underspend of 50% or greater when compared to those not considered to be underspending. This is shown in Table 4.

Table 4: Householder reported heating hours per week of underspending households

Household considered to be underspending?	Sample size	Number of households (000s)	Median reported number of heating hours per week, including boost heating	
			(Hours)	95% C.I.
Not considered to be underspending	456	7,254	58.5	(55, 62)
All considered to be underspending	889	14,640	57.0	(54, 60)
Considered to be underspending by more than 25%	449	7,546	54.3	(50, 58)
considered to be underspending by more than 50%	100	1,727	44.0	(35, 53)

Base: All households in both of the EFUS 2011 meter reading sample (n = 1345).

These results provide good evidence that underspending households are heating to lower temperatures, than those that are not considered to be underspending. Those that have the largest underspend (underspend > 50%) also report heating for a shorter period of time. Reduced temperatures and shorter periods of heating are likely to be major reasons why actual expenditure on fuel of these households is below that calculated under the fuel poverty heating regime standard.

3.1.2 Underspend by household characteristics

Bivariate analysis of the characteristics of underspending households have been examined. These results are shown in Table 5. Detailed descriptions of the variables used or derived from the EHS and EFUS data can be found in the Glossary.

Table 5: Percentage of underspending households by household characteristics

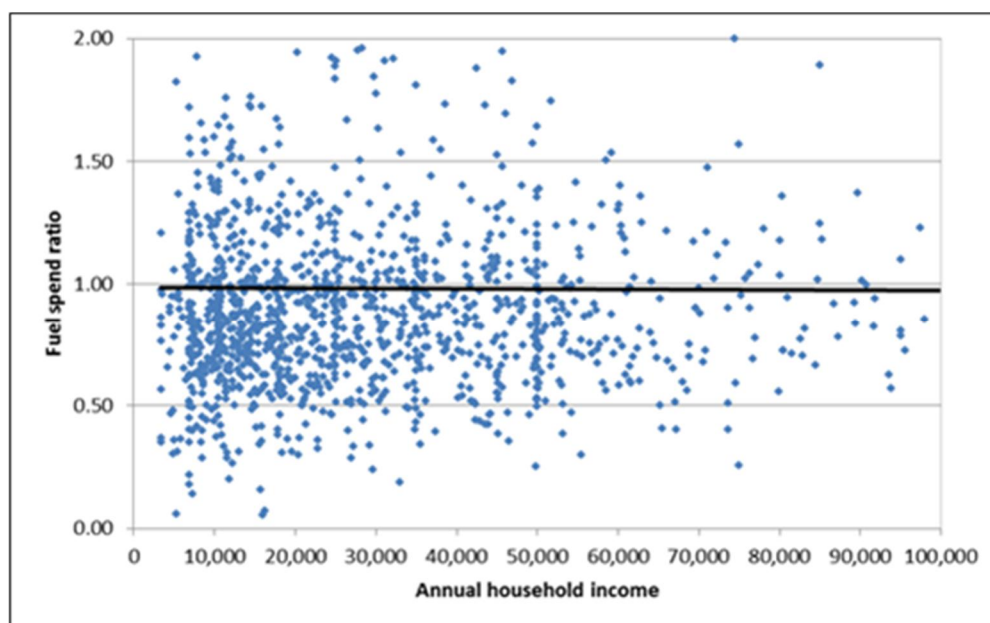
Household characteristic	Characteristic category	Sample size	% of group considered to be underspending	95% C.I.
Tenure	Owner Occupied	862	67	(63.8, 70.7)
	Private rented	144	72	(64.4, 80.5)
	Local Authority	176	58	(50.4, 66.4)
	RSL	163	64	(55.4, 71.7)
Number of persons in household	1	352	70	(64.4, 74.9)
	2	514	69	(64.6, 73.4)
	3	225	61	(53.7, 67.8)
	4	167	68	(60.3, 75.9)
	5 or more	87	57	(45.7, 68.6)
Pensioner Present	At least one person of pensionable age	553	68	(63.5, 72.0)
	No persons of pensionable age	792	66	(62.7, 70.0)

Any children present?	At least one child	387	63	(57.7, 68.3)
	No children	958	68	(65.2, 71.7)
Age of HRP	16 – 34	152	68	(60.0, 76.3)
	35 – 44	234	66	(58.8, 72.2)
	45 – 54	257	63	(57.0, 69.9)
	55 – 64	280	69	(63.5, 75.4)
	65 – 74	260	68	(61.3, 73.9)
	75 or more	162	68	(60.1, 75.9)
Employment status of HRP and partner combined	1 or more work full time	646	67	(62.7, 70.7)
	1 or more work part time	116	62	(52.8, 72.2)
	none working, one or more retired	448	68	(63.6, 73.0)
	none working and none retired	135	68	(59.0, 76.3)
Income quintile	1st quintile (lowest)	291	69	(63.2, 74.9)
	2nd quintile	285	69	(62.7, 74.5)
	3rd quintile	254	67	(61.0, 73.7)
	4th quintile	250	62	(55.7, 68.9)
	5th quintile (highest)	265	67	(60.8, 73.3)
Is anyone in the household at home during the day on a weekday?	No	514	66	(61.4, 70.4)
	Yes	831	68	(64.1, 71.1)
Household is under-occupying?	Not under-occupying	867	68	(64.1, 71.0)
	Under-occupying	478	66	(61.0, 70.3)
In Fuel Poverty? LIHC definition	Not in fuel poverty	1177	65	(61.9, 67.9)
	In fuel poverty	168	80	(73.6, 86.9)

Base: All households in the EFUS meter reading sample (n = 1,345).

It can be seen that there are no clear differences in the any of the likelihood of households considered to be underspending, with the exception whether a household is considered to be in fuel poverty. Simply being on low income is not a good predictor of underspending. This is apparent in Table 5 and also the scatterplot shown in Figure 1, there is no correlation between household income and the ratios of actual fuel spend to notional fuel spend requirement. Income alone does not appear to be the primary driver of household underspend, with many low income households able to meet (and often exceed) the fuel poverty heating regimes. From the other relationships (fuel poverty and energy efficiency) presented below, it seems likely that this is particularly the case in energy efficient dwellings, although additional analysis is required to investigate this further.

Figure 1: The relationship between household income and the fuel spend ratio.



Where income is combined with an energy requirement for the home, however, a correlation becomes apparent. This is done in the classification of a household as fuel poor or otherwise. Households that are fuel poor are more likely to be considered underspending than non-fuel poor households. 80% of those defined as fuel poor are actually spending below the defined standard, compared to 65% of the non-fuel poor group.

This relationship is expected. As described in the introduction to this report, the concept of household underspend is closely associated with the concept of fuel poverty, which aims to identify those households where energy is unaffordable. Both indicators are linked through a common aspect of their methodologies (i.e. use of a defined notional heating regime for each household), and can be seen as complementary indicators of when a household may be finding it difficult to heat their homes.

3.1.3 Underspend by dwelling characteristics

The prevalence of underspend by key dwelling characteristics is shown in Table 6.

Table 6: Percentage of underspending households by dwelling characteristics

Dwelling characteristic	Characteristic category	N (raw sample size)	% of group considered to be underspending	95% C.I.
Dwelling type	End terrace	146	61	(52.2, 69.6)
	Mid terrace	223	65	(58.0, 71.8)
	Semi detached	387	69	(63.6, 73.7)
	Detached	255	69	(62.9, 75.4)
	Bungalow	141	73	(65.0, 81.1)
	Flat	193	64	(56.5, 71.4)
Dwelling type	house or bungalow	1152	67	(64.5, 70.4)
	flat	193	64	(56.5, 71.4)

Dwelling Age	Pre 1919	206	78	(71.4, 83.9)
	1919-1944	232	73	(66.9, 79.4)
	1945-1964	326	65	(59.4, 70.8)
	1965-1974	210	64	(57.0, 71.3)
	1975-1980	92	63	(51.7, 73.5)
	1981-1990	108	74	(64.7, 83.0)
	Post 1990	171	47	(38.6, 55.0)
Useable floor area	< 50 m ²	133	71	(62.7, 79.7)
	50 to 69 m ²	292	58	(51.9, 64.4)
	70 to 89 m ²	396	70	(65.3, 75.2)
	90 to 109 m ²	199	72	(65.5, 79.1)
	110 to 139 m ²	154	67	(58.7, 75.0)
	>=140 m ²	171	64	(56.3, 72.1)
Region - EHS order	North East	98	66	(55.6, 76.2)
	North West	219	65	(58.4, 72.3)
	Yorkshire and the Humber	183	71	(63.4, 78.0)
	East Midlands	95	70	(59.5, 79.9)
	West Midlands	128	67	(57.9, 75.9)
	East	158	71	(63.7, 79.2)
	London	134	68	(59.7, 77.0)
	South East	183	60	(52.0, 67.6)
	South West	147	67	(58.1, 74.9)
Is dwelling in an urban or rural location?	Urban	1209	67	(64.5, 70.3)
	Rural	136	62	(53.3, 71.2)
Type of heating system	Central Heating	1256	66	(62.8, 68.6)
	Non-Central Heating	89	83	(73.9, 91.2)
Main heating fuel	Mains gas	1178	65	(62.0, 68.0)
	Electricity	78	84	(74.8, 92.8)
	Other (bottled/bulk gas, solid, oil, community scheme)	89	74	(64.5, 84.4)
Are the walls of the dwelling insulated?	Insulated	648	58	(54.3, 62.6)
	Not insulated	697	73	(69.6, 76.9)
Loft insulation	<50mm	75	80	(69.8, 89.8)
	50-149mm	525	68	(63.7, 72.5)
	150+ mm	611	67	(62.5, 70.7)
Is dwelling fully double glazed?	Yes	1038	64	(61.0, 67.4)
	No	307	75	(69.7, 80.3)
How many insulation measures does the dwelling have?	All 3 insulation measures	253	62	(55.1, 68.3)
	2 insulation measures	403	63	(57.4, 67.8)
	1 insulation measure	408	73	(68.0, 77.5)
	No insulation measures	147	77	(69.8, 84.7)
Energy efficiency (SAP09) rating	less than 30	35	90	(79.1, 100)
	30 to 50	293	82	(76.9, 86.6)
	51 to 70	902	63	(59.8, 66.7)
	more than 70	115	47	(37.4, 57.4)

Base: All households in the EFUS 2011 meter reading sample (n = 1,345).

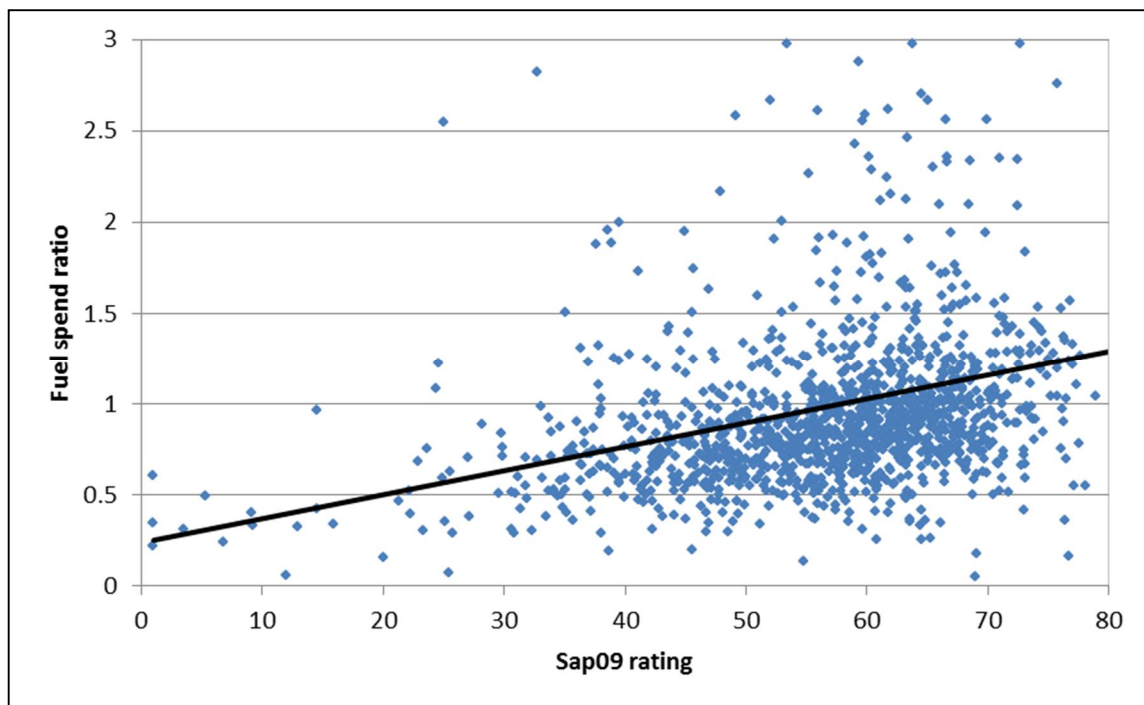
Significant differences are found between the proportions of properties considered to be underspending by property age. In general, the older the property, the higher the proportion of households that are underspending (although not all differences are statistically significant). This general trend is likely to be closely linked to the energy efficiency of the property, discussed below. Over three quarters of households living in properties built pre 1919 are considered to be underspending, ranging down to less than half of those living in properties built post 1990. The level of underspend does not differ significantly between properties of different size and type (semi-detached, flats etc).

A significant relationship is apparent between a home's energy efficiency rating (SAP) and the percentage of households considered to be underspending. Households living in dwellings with poor energy efficiency are much more likely to be considered underspending. At progressively higher energy efficiency bands the likelihood of underspend decreases.

The proportion of households considered to be underspending ranges from less than 47% of all homes with a SAP rating > 70, to 90% of homes in with SAP ratings below 30.

This correlation between SAP rating and underspend has been investigated further. There is a significant correlation between the proportion of the fuel cost requirement actually spent (i.e. the actual fuel spend / notional fuel spend), and the SAP rating itself. As the SAP rating decreases the level of underspend increases. This is shown in the scatter plot in Figure 3. This relationship is important as it demonstrates that higher energy efficiency dwellings are more likely to use the energy the fuel poverty definitions consider they require (or indeed, more than the definitions consider they require), whereas lower energy efficiency dwellings will not.

Figure 2: Scatterplot of SAP rating versus actual / notional fuel expenditure ratio



Base: All households in the EFUS 2011 meter reading sample (n = 1345). Line of best fit is $y = 0.013x + 0.24$.

On average, properties with a SAP rating above 60 are found to spend the required amount or more. Properties rated lower are found to spend less. This relationship has a number of potential implications. In particular, it may indicate that energy efficiency improvements to poorly performing properties may simply reduce the level of underspend, rather than deliver the full reduction in energy consumption anticipated. It is, however, important to recognise that these results are not those from a pre- and post- improvement analysis, and other differences (rather than energy efficiency) between the groups may also be responsible for this effect. Overestimation of energy use by BREDEM in different house types may also be a factor.

A significantly higher percentage of households living in dwellings heated by systems other than gas boilers with radiators, are found to underspend. This relationship with heating systems may reflect the relative cost of heating to the required levels of different systems, which may be unaffordable with less efficient heating systems, or indeed the relative ease of heating with central heating systems as opposed to other less centralised systems.

The strong relationship with energy efficiency can also be seen in the relationship between underspending and insulation level in Table 6. The proportion of households which are considered to be underspending is significantly higher for those living in poorly insulated dwellings, than well insulated dwellings.

4 Conclusions

The fuel poverty methodology, used to produce estimates of fuel poverty in England, defines a regime which is considered sufficient to provide adequate energy for heating and other uses in the home. This includes energy for heating, lighting, appliance use and cooking. A household is said to be underspending when it is not spending sufficiently to meet this regime.

The EFUS, by collecting information on the consumption and tariffs of households across England, has allowed us to examine the prevalence of underspending, and how it is associated with a number of key households and dwelling characteristics.

- Approximately 67% of all households are underspending compared to the fuel bill calculated using the English fuel poverty methodology.
- Approximately 35% of all households are underspending by more than 25% of this fuel bill.
- Approximately 8% of all households are underspending by more than 50% of this fuel bill.

Households that are considered to be underspending have lower mean internal temperatures, and lower demand temperatures than those that are not. Households who are considered to be underspending by more than 50% also report heating for fewer hours on average than those not considered to be underspending.

Those households that are in fuel poverty are more likely to be considered underspending than those that are not, with around 80% of those in fuel poverty considered to be underspending.

These results provide good evidence of an overlap between the definitions of fuel poverty and underspend, and suggest that the fuel poverty indicator is relatively well targeted at those that are considered to be underspending.

There is no clear relationship between underspending and income. Low income households are as likely to be underspending as high income households. Similarly, the likelihood of a household underspending is not clearly related to other household factors including household type, age of household or employment status.

There are, however, clear relationships with energy efficiency described by the dwellings SAP ratings. Those households living in higher energy efficiency properties are less likely to be considered underspending than those in lower band. Approximately 90% of those living in the least energy efficient properties (i.e. those with a SAP rating below 30) are considered to be underspending, compared to 47% considered to be underspending in the most energy efficient properties (SAP >70).

This relationship with energy efficiency is reflected in fact that households in older properties are more likely to underspend, as are those without gas central heating systems, in poorly insulated properties.

If a household is considered to be underspending, it indicates that the total fuel bill of the household is below that required by the Fuel Poverty methodology. The fuel poverty fuel bill is constructed to represent a sufficient standard of heating and other energy use for the household, but the high

proportion of households that are considered to be underspending indicates that these regimes are higher than actual consumption for the majority of households. When placing these findings in the context of the other findings from the EFUS, this is perhaps un-surprising. The EFUS has found that heating hours and periods are generally less than typically assumed, as are temperatures achieved in households.

One of the most interesting observations from this study is the inverse relationship between underspend and energy efficiency. At higher levels of energy efficiency, the fuel poverty heating regime is increasingly likely to be achieved or surpassed, and households that are underspending are become rarer. It appears that the poor energy efficiency of the property is preventing this standard being reached in dwellings of poor energy efficiency. This relationship between energy efficiency and underspend could have a number of significant policy implications. In particular, it highlights that improvements made to poorly performing properties may act to reduce the level of underspend, rather than deliver the theoretical reductions in consumption which may be anticipated.

The suitability and applicability of the fuel poverty regimes do not form part of the scope of this particular piece of work, and are not commented on to any extent as part of this report. Underspend defined in this way assumes that these regimes are appropriate standards for energy consumption. It is, however, recommended that further analysis considers these issues as recommended by the recent Hills Fuel Poverty Review.

Glossary

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 householder responses to q167/168/169/170 in the EFUS 2011 Interview survey for new households and from variables obtained from the EHS Interview survey for households that had not changed since the earlier EHS interview.
Annual gross income of the HRP and partner weighted quintiles:	This is the annual income of the Household Reference Person and (any) partner. This includes income from private sources (regular employment, self-employment, government schemes, occupational pensions, private pensions and other private income), state benefits/allowances and tax credits, as collected on the EHS survey (this includes housing benefit/Local Housing Allowance but excludes council tax benefit and Support for Mortgage Interest) and interest from savings. It is a gross measure i.e. income before Income Tax or National Insurance deductions.
Children Present:	Anyone in the household who is 16 years old or younger. Derived from householder responses to q167/168/169/170 in the EFUS 2011 Interview survey for new households and from variables obtained from the EHS Interview survey for household that had not changed since the EHS interview.
Dwelling insulation:	The number of insulation measures where positive responses for 'Fully double glazed', 'Insulated walls' and having loft insulation greater than 200mm count as insulation measures.
Dwelling type:	Classification of dwelling on the basis of the surveyors' inspections during the EHS physical survey.
Employment status of HRP and Partner combined:	Information on employment status was not re-collected as part of the EFUS and is as reported in the EHS interview survey (and some households may have changed status in the period between the two interviews).
Fuel Poverty – LIHC	Under the Low Income High Cost definition a household is considered to

definition:	<p>be fuel poor where:</p> <ul style="list-style-type: none"> • 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. <p>Please refer to the following documents for more information.</p> <p>https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66570/6406-fuel-poverty-changing-the-framework-for-measureme.pdf</p> <p>https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/226988/fuel_poverty_stats_methodology_handbook_2013.pdf</p>
Fully double glazed:	Derived from the 'dblglaz4' variable as measured by surveyors in the EHS physical survey. Fully double glazed is 'entire house double glazed'. Not fully double glazed is anything less than fully double glazed.
Household size:	Number of persons in the household, banded into 5 groups, derived from the 'hhsizex' variable from the EHS Interview survey.
In during the day:	See the EHS interview documentation for full details of occupancy questions asked as part of the EHS (question 'Hmwtht'). A household has been classified as being 'in during a weekday' if they indicate being generally in the house on weekdays during the winter, for any period between 9am and 5pm. It should be noted that this information was not re-collected as part of the EFUS, and some households occupancy patterns may have changed in the interval between the two interview surveys.
Insulated walls:	Derived from the 'wallinsx' variable as measured by surveyors in the EHS physical survey. 'Insulated' are 'cavity with insulation'; 'Not insulated' includes 'cavity without insulation' and 'other' wall types.
Loft insulation:	Banded variable of 'loftinsx', the level of loft insulation recorded by surveyors in the EHS physical survey.
Main fuel:	As determined 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.
Pensioner Present:	Anyone in the household who is 65 or over (male) or 60 or over (female). Derived from householder responses to q167/168/169/170 in the EFUS 2011 Interview survey for new households and from variables obtained from the EHS Interview survey for households that had not changed since the EHS interview.

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).
Tenure:	Derived from householder responses to q01 in the EFUS 2011 Interview survey.
Type of heating:	Central heating or non-central heating. Determined from householder responses to Q06 in EFUS 2011 interview survey. Non-central heating includes storage radiators, gas fires, electric heaters, coal/wood/smokeless fuel fires or stoves and other.
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: http://www.decc.gov.uk/assets/decc/Statistics/fuelpoverty/614-fuel-poverty-methodologyhandbook.pdf
Useable floor area:	The total usable internal floor area of the dwelling as measured by the surveyor in the EHS physical survey, 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 5 categories.