

Understanding 'High Use Low Income' Energy Consumers

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1. Introduction

1.1. Expenditure and Food Survey

The analysis for this study uses the dataset developed for CSE's 'Distributional Impacts Model for Policy and Strategic Analysis' – or 'DIMPSA'. This uses three years' of UK Expenditure and Food Survey (EFS) data (covering April 2004 – December 2007)¹, which have been combined into one dataset, increasing the sample size to over 20,000 cases. Data on household expenditure on heating fuels contained in the EFS is converted to annual consumption (in kWh) using method of payment and time- and location-specific fuel price information². For the purpose of this study all analysis has been limited to households in Great Britain and "energy" consumption is based on the derived values for electricity and gas consumption (i.e. the consumption of non-metered fuels are not included in the analysis).

1.2. Data health warnings

The EFS collects data on household expenditure via a survey and diary-based methods, depending on the item in question. The EFS is designed to give an accurate mean value of expenditure at the aggregate level, but not the individual case. The nature of this approach means that resulting fuel consumption values for any one case cannot necessarily be assumed to give a representative estimation of energy consumption over the year for the individual household. As such, analysis has to be undertaken with sufficiently large groups of cases³ to maintain a representative mean value.

Data on fuel expenditure by prepayment meter in the EFS is collected via the diary. As a result this method of payment is subject to records with zero values. CSE is currently undertaking further research to determine the significance of this. Whilst zero values are valid in the EFS, it is likely that the distribution of expenditure (and therefore fuel consumption) is exaggerated as a result. With prepayment meters being prevalent in low income households, this may result in an underestimate of consumption for this subset. Whilst all distributional analysis is undertaken using a statistical technique that maintains sufficient sample sizes to give a reliable estimate of consumption, with analysis for this study being restricted to the low income subset, consumption values should be treated with some caution.

The resulting totals for household fuel consumption calculated from EFS expenditure data have not been reconciled with those published in the UK Digest of Energy Statistics (DUKES), with the latter being higher than the former. Whilst fairly simple to do, inflating the EFS totals to correlate with DUKES may introduce further margin for error. Furthermore, the DUKES figures themselves contain some consumption from Small and Medium Sized Enterprises (SMEs) that are on domestic tariffs, and are also weather corrected, whereas the EFS data is based on non-weather corrected energy expenditure.

¹ From January 2008, the EFS became known as the Living Costs and Food Survey (LCF), a module of the Integrated Household Survey (IHS). www.esds.ac.uk/government/efs/

² Information on energy supplier is not available.

³ Set at 200 cases in a normally weighted EFS dataset

1.3. Further research

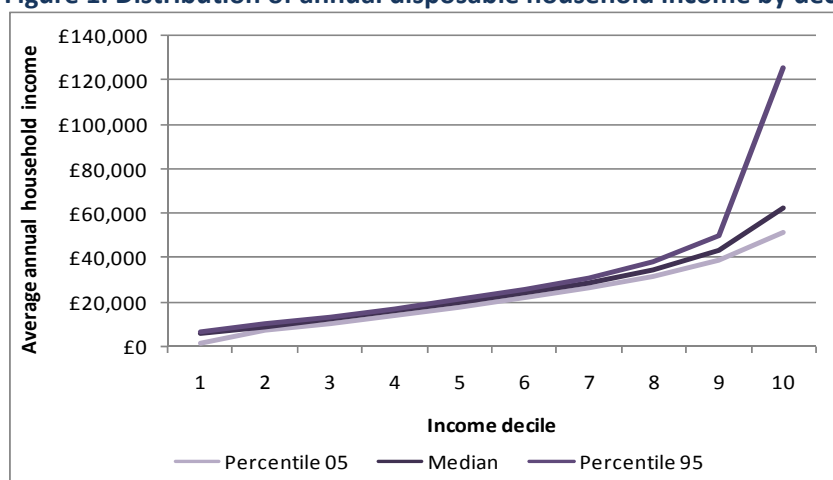
CSE is currently working with the University of Bristol Townsend Centre and the University of Oxford Environmental Change Institute to deliver a Joseph Rowntree Foundation funded project looking at the social impacts of climate change policies. The study will create a GB wide dataset showing the distribution of carbon dioxide emissions with an England subset that contains both current household energy consumption and the level of energy consumption that would be required for the household to achieve adequate levels of warmth and other energy services. Once developed, this dataset will offer significant potential to further our understanding of the energy consumption patterns of low income households.

2. Household income and energy consumption

2.1. Household income

The focus of this study is on understanding energy consumption patterns of low income households. There are a number of different approaches to measuring income and defining low income/ poverty status. The measure of income used here is 'normal weekly disposable household income' as defined in the Expenditure and Food Survey⁴, (with the weekly values inflated to represent annual income). Figure 1 shows the distribution of annual household disposable income by decile in the GB EFS dataset.

Figure 1. Distribution of annual disposable household income by decile in the EFS



For the purpose of this study, 'low income' households are defined as those in disposable income deciles 1 and 2 (income quintile 1). The upper threshold of this income quintile in the EFS dataset is £10,533 (Table 1).

The commonly used threshold of 'low income' in poverty analysis is an annual household income of 60% or less of the average (median) British household income in that year⁵. For the EFS dataset used in this study, median income is £21,817, giving a 60% threshold of £13,090. Using this definition the majority of households in disposable income decile 3 would also be defined as 'low income', as shown in Table 1 below.

Using the two approaches discussed above, this study applies a wholly income-based approach to exploring the energy consumption patterns of poor households in Great Britain. Ranking households by their expenditure rather than income offers an alternative approach to distributional analysis. Whilst not included in the detailed analysis in this study, this expenditure-based approach is discussed in Annex 4.

⁴ "Normal weekly disposable household income" [P389] = (Sum of all i.e. every person in the household) "Personal gross income, less tax and National Insurance contributions" [p177], Expenditure and Food Survey 2007, Volume F derived variables.

⁵ www.poverty.org.uk/01/index.shtml

Table 1. Annual household income by decile in the EFS

| Decile | Mean | Median | Maximum | HHs not in income poverty | HHs in income poverty | Total households |
|----------------|----------------|----------------|-------------------|---------------------------|-----------------------|-------------------|
| 1 | £5,070 | £5,719 | £7,179 | - | 2,420,858 | 2,420,858 |
| 2 | £8,895 | £8,918 | £10,533 | - | 2,420,364 | 2,420,364 |
| 3 | £12,158 | £12,096 | £13,894 | 527,944 | 1,892,655 | 2,420,599 |
| 4 | £15,726 | £15,721 | £17,685 | 2,421,073 | - | 2,421,073 |
| 5 | £19,731 | £19,703 | £21,817 | 2,420,897 | - | 2,420,897 |
| 6 | £24,052 | £24,013 | £26,394 | 2,420,495 | - | 2,420,495 |
| 7 | £28,926 | £28,886 | £31,681 | 2,420,765 | - | 2,420,765 |
| 8 | £35,023 | £34,855 | £38,841 | 2,420,441 | - | 2,420,441 |
| 9 | £44,016 | £43,493 | £50,840 | 2,420,067 | - | 2,420,067 |
| 10 | £74,049 | £62,570 | £1,885,978 | 2,421,192 | - | 2,421,192 |
| Overall | £26,765 | £21,817 | £1,885,978 | 17,472,874 | 6,733,877 | 24,206,751 |

2.2. Household energy consumption

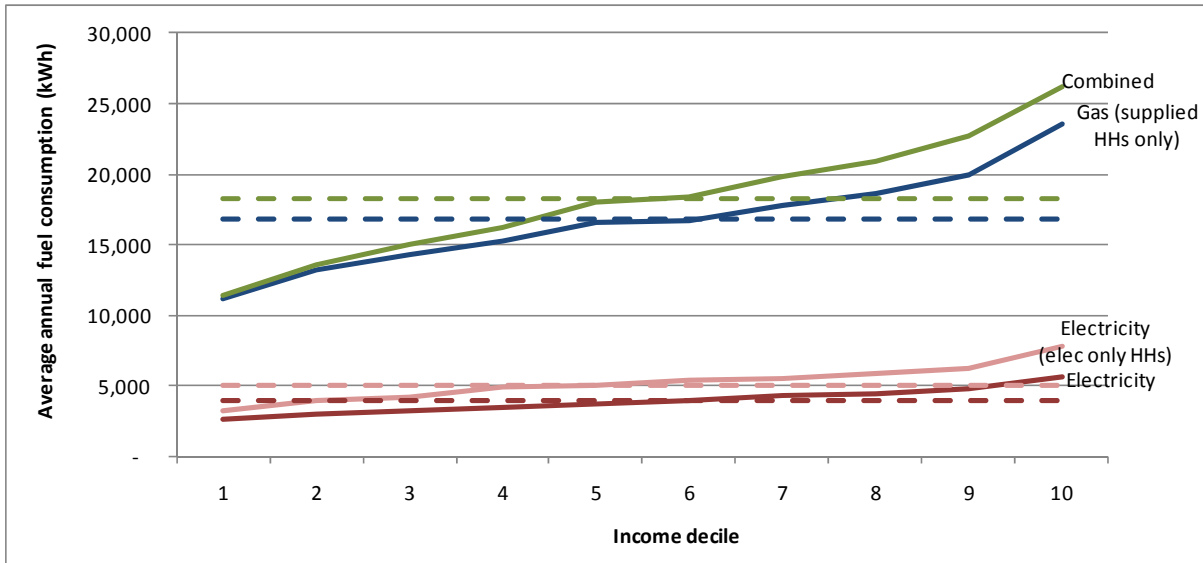
The average annual household consumption of electricity, gas and the two fuels combined by income decile and overall in the (GB) EFS dataset is shown below. Two sets of values for electricity and gas consumption are shown, to differentiate between the whole population and electricity only/gas supplied households⁶. Median consumption for each decile is shown in Annex Figure 1.

Table 2. Average annual household fuel consumption (kWh) by income decile

| Income decile | Electricity | Electricity (elec. only HHs) | Gas | Gas (supplied HHs only) | Elec & Gas Combined |
|------------------|---------------|------------------------------|---------------|-------------------------|---------------------|
| 1 | 2,608 | 3,273 | 8,758 | 11,200 | 11,366 |
| 2 | 2,967 | 3,913 | 10,631 | 13,191 | 13,598 |
| 3 | 3,204 | 4,180 | 11,767 | 14,268 | 14,971 |
| 4 | 3,510 | 4,933 | 12,750 | 15,221 | 16,261 |
| 5 | 3,715 | 5,070 | 14,259 | 16,616 | 17,975 |
| 6 | 3,942 | 5,418 | 14,497 | 16,650 | 18,439 |
| 7 | 4,263 | 5,554 | 15,538 | 17,732 | 19,801 |
| 8 | 4,393 | 5,903 | 16,498 | 18,570 | 20,892 |
| 9 | 4,845 | 6,220 | 17,815 | 19,928 | 22,660 |
| 10 | 5,585 | 7,764 | 20,670 | 23,589 | 26,255 |
| Mean | 3,903 | 4,976 | 14,318 | 16,817 | 18,222 |
| Median | 3,426 | 4,295 | 13,413 | 15,375 | 16,886 |
| N ('000s) | 24,207 | 3,601 | 24,207 | 20,606 | 24,207 |

⁶ There are some 3.6 million households in the EFS that do not have a gas supply. As such these households have a valid 'zero' expenditure on gas – see section 1.2 for a discussion of zero records in the EFS.

Figure 2. Mean annual household fuel consumption by income decile (dashed lines show the overall mean for the dataset)



As Figure 2 illustrates, the variation in consumption between income deciles is much more pronounced for gas (with a higher standard deviation) than for electricity. This is related to the difference in heating fuels across the deciles (Figure 3). Gas central heating, and indeed access to gas at all, is less common in the lower income deciles, hence gas consumption for a large proportion of these households is zero. It follows that a reliance on electricity for heating is more common among lower income households, hence increasing the average consumption of this fuel to nearer that of the higher income deciles (Figure 5).

Figure 3. Central heating type by income decile (dashed lines show mean for dataset)

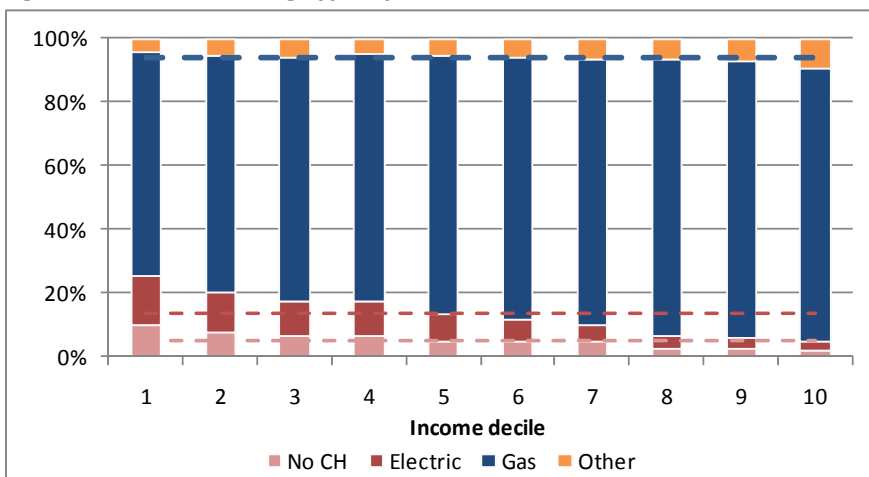


Figure 4. Access to gas by income decile (dashed lines show mean for dataset)

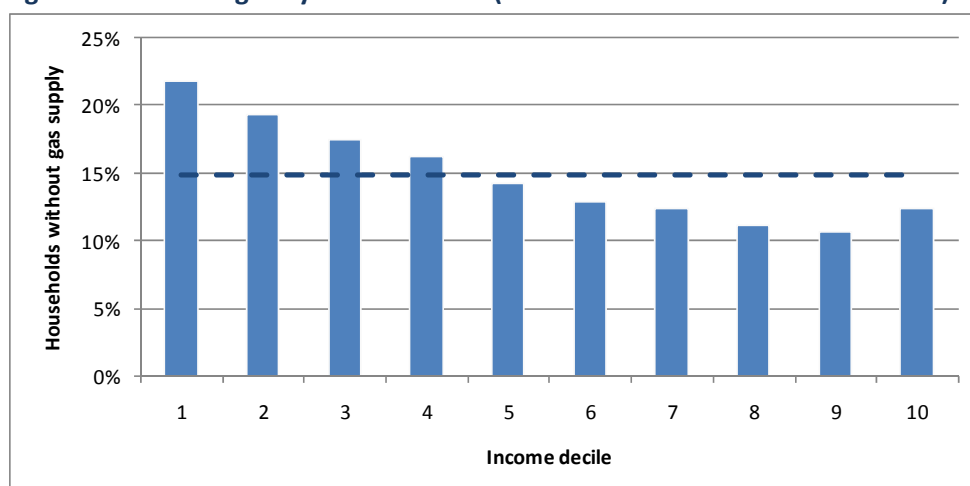
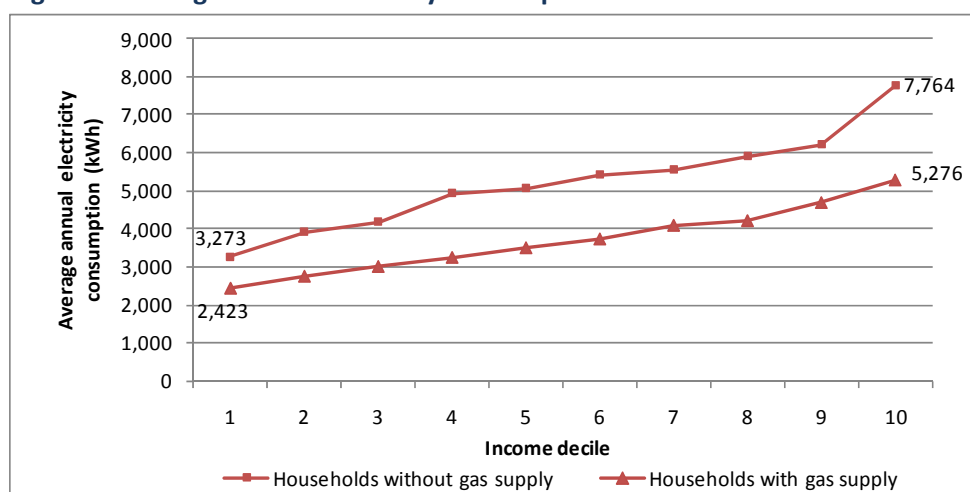


Figure 5. Average annual electricity consumption of households with and without a gas supply

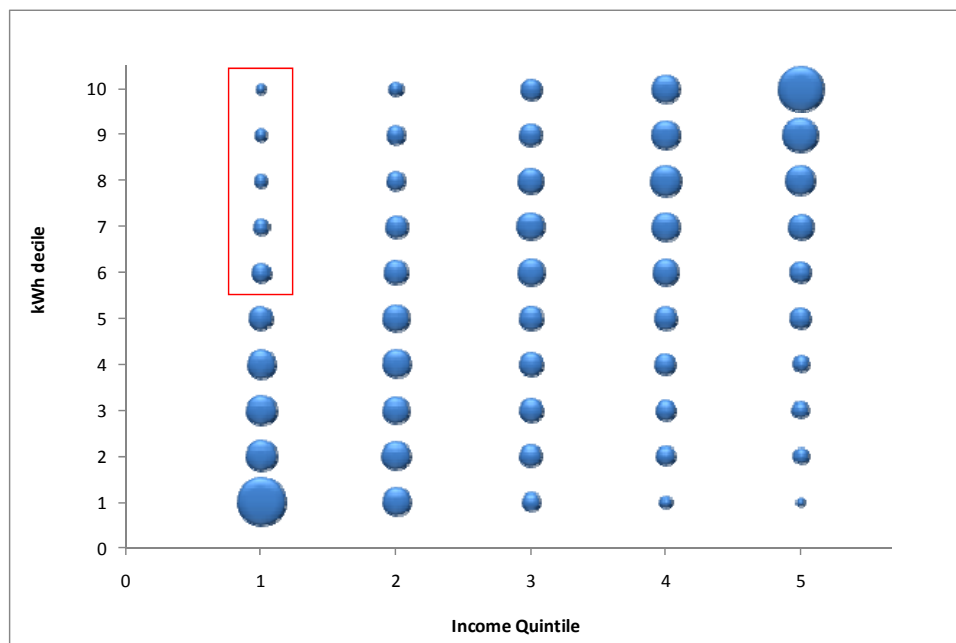


As discussed above, the nature of the EFS dataset does not lend itself to distributional analysis at the case level. However, deciling energy consumption in the EFS dataset and cross-tabulating this with income bands does give an indication of the consumption patterns within income quintiles (quintiles are used to maintain sufficient sample sizes), as shown in Table 3, and illustrated in Figure 6. Cells outlined in red show low income deciles with an above mean energy consumption.

Table 3. Number of households by income quintile and energy consumption decile

| Income quintile | Energy consumption deciles | | | | | | | | | |
|-----------------|----------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1 | 1,044,632 | 666,617 | 630,770 | 599,177 | 485,028 | 388,328 | 312,192 | 277,265 | 236,629 | 200,584 |
| 2 | 581,615 | 590,455 | 560,223 | 582,701 | 550,747 | 501,397 | 450,250 | 375,704 | 371,055 | 277,525 |
| 3 | 371,671 | 455,532 | 483,869 | 487,308 | 500,867 | 565,770 | 566,319 | 529,835 | 459,715 | 420,506 |
| 4 | 254,628 | 391,817 | 411,554 | 424,195 | 458,398 | 536,948 | 572,859 | 623,385 | 610,296 | 557,127 |
| 5 | 168,132 | 316,795 | 333,877 | 326,879 | 426,374 | 427,685 | 519,029 | 614,910 | 742,329 | 965,249 |

Figure 6. Distribution of households by income quintile and energy consumption decile (width of bubbles represents (weighted) number of households)



2.3. 'Above average' consumers

Table 3 and Figure 6 above clearly show a group of low income high consuming households. Of specific interest to this study are the low income households with 'above average' energy consumption. Households that exceed the mean level of electricity, gas and combined fuel consumption in the GB EFS (see Table 2 for means) are shown in Table 4 and Figure 7 below. Keeping with the low income definition described above (households in income deciles 1 and 2), this shows that in the EFS dataset there are some 1.14 million, 1.0 million and 1.22m 'low income' households with above average electricity, gas and combined fuel consumption respectively (where the figures for gas, in both the table and graph, are based on the GB EFS subset of households with a gas supply).

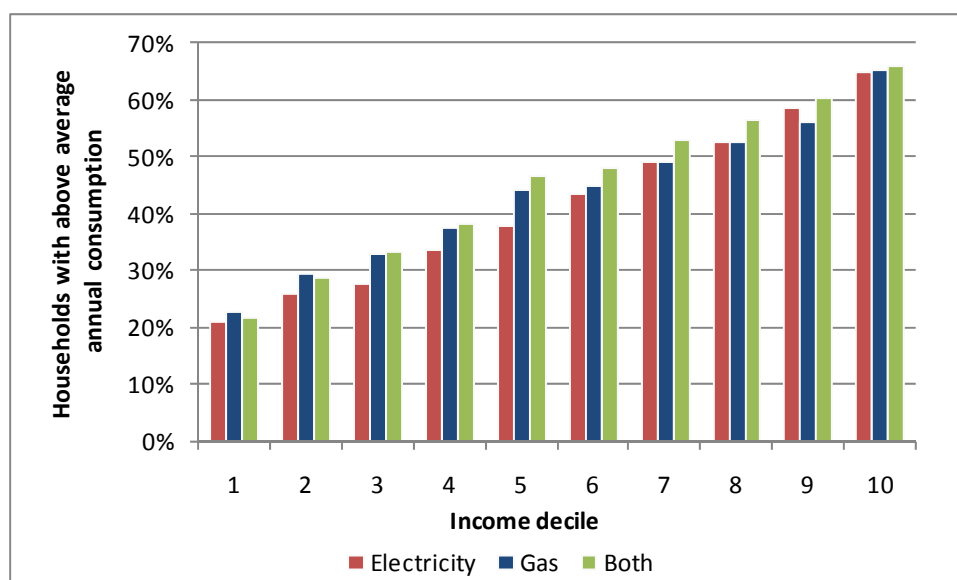
Applying the standard income poverty definition (annual household income less than 60% of median) sees these figures increase, as some households in quintile 2 are also 'poor' by this definition. Some 1.7m, 1.5m and 1.9m households in income poverty have above average energy consumption. This is around one third of all households defined as 'poor' according to this definition.

To further understand the nature of the group of low income high ('above average') consumers, CHAID analysis can be undertaken, as described in section 3.

Table 4. Number (thousands) and percentage of households with above mean fuel consumption (figures in brackets show the percentage with above median consumption)

| Income quintile | Electricity | | | Gas (supplied HHs) | | | Combined | | |
|--|---------------|------------|--------------|--------------------|------------|--------------|---------------|------------|--------------|
| | Count | % | (%) | Count | % | (%) | Count | % | (%) |
| 1 | 1,139 | 24% | (29%) | 1,006 | 26% | (31%) | 1,224 | 25% | (29%) |
| 2 | 1,485 | 31% | (39%) | 1,420 | 35% | (41%) | 1,727 | 36% | (41%) |
| 3 | 1,970 | 41% | (50%) | 1,861 | 44% | (52%) | 2,290 | 47% | (53%) |
| 4 | 2,458 | 51% | (61%) | 2,169 | 51% | (57%) | 2,644 | 55% | (60%) |
| 5 | 2,984 | 62% | (70%) | 2,595 | 61% | (66%) | 3,064 | 63% | (68%) |
| Total | 10,036 | 41% | (50%) | 9,051 | 37% | (50%) | 10,949 | 45% | (50%) |
| Households in 'income poverty' with above average consumption | 1,663 | 25% | (31%) | 1,527 | 28% | (34%) | 1,867 | 28% | (32%) |

Figure 7. Proportion of households with above (mean) average fuel consumption by income decile



3. Characterising low income high users

The broad analysis of energy consumption by income decile in the previous section gives an indication of the distribution of consumption patterns but fails to provide an overview of the fundamental drivers of low income, high consumption households. The process of chi-squared automatic interaction detector (CHAID) can be used to assist in identifying the key defining characteristics of this group of households.

CHAID is a classification method which seeks to identify optimal splits in categorical 'predictor' variables with respect to their influence upon a single dependent variable - in this case household energy consumption. This results in clusters - or 'nodes' - of cases with similar defining characteristics and to which a predicted value for the dependent variable is assigned. The predicted value is equivalent to the mean consumption of all cases in the node. Running CHAID on the (GB) EFS dataset and creating these nodes therefore has the advantage that it enables more detailed analysis of the socio-demographics of low income high consumers, whilst maintaining a sufficient number of cases (set at 200 cases in the normally weighted dataset) to give a reliable prediction of household fuel consumption.

Three different CHAID models are run here, where the dependent variable is, respectively: annual household consumption of electricity, gas and both fuels combined. All models are initially applied only to the 'low income' subset of interest (i.e. households in income deciles 1 and 2; n = 4,841,222).

However, for comparison purposes, the same models are then run on the subset of households in 'income poverty' (i.e. household income less than 60% of the median; n = 6,733,864). This captures all households in income deciles 1 and 2 included in the previous models, plus an additional 1.89m households in income decile 3 that fall into this definition. As such, the model should help to identify any key defining characteristics of these additional high consumption 'poor' households.

3.1. Electricity consumption

The dependent variable in this CHAID model is annual household electricity consumption (in kWh). The predictor variables selected by the model as having a significant relationship with electricity consumption are shown below.

Table 5. Predictor variables selected by the CHAID model for electricity consumption

| | |
|---------------------------|---|
| • Central heating type | • Annual household disposable income |
| • Rooms in accommodation | • Category of dwelling |
| • Tenure | • Number of adults |
| • Age of HRP ⁷ | • Priority Group ⁸ |
| • Govt. Office Region | • In receipt of (means-tested) benefits |

The CHAID model run on the low income subset (households in income deciles 1 and 2 only, n = 4,841,222) resulted in 17 nodes. The distribution of these nodes is shown on the histogram below,

⁷ HRP = Household Reference Person, defined as the householder with the highest income (or the oldest of two or more householders with the same income).

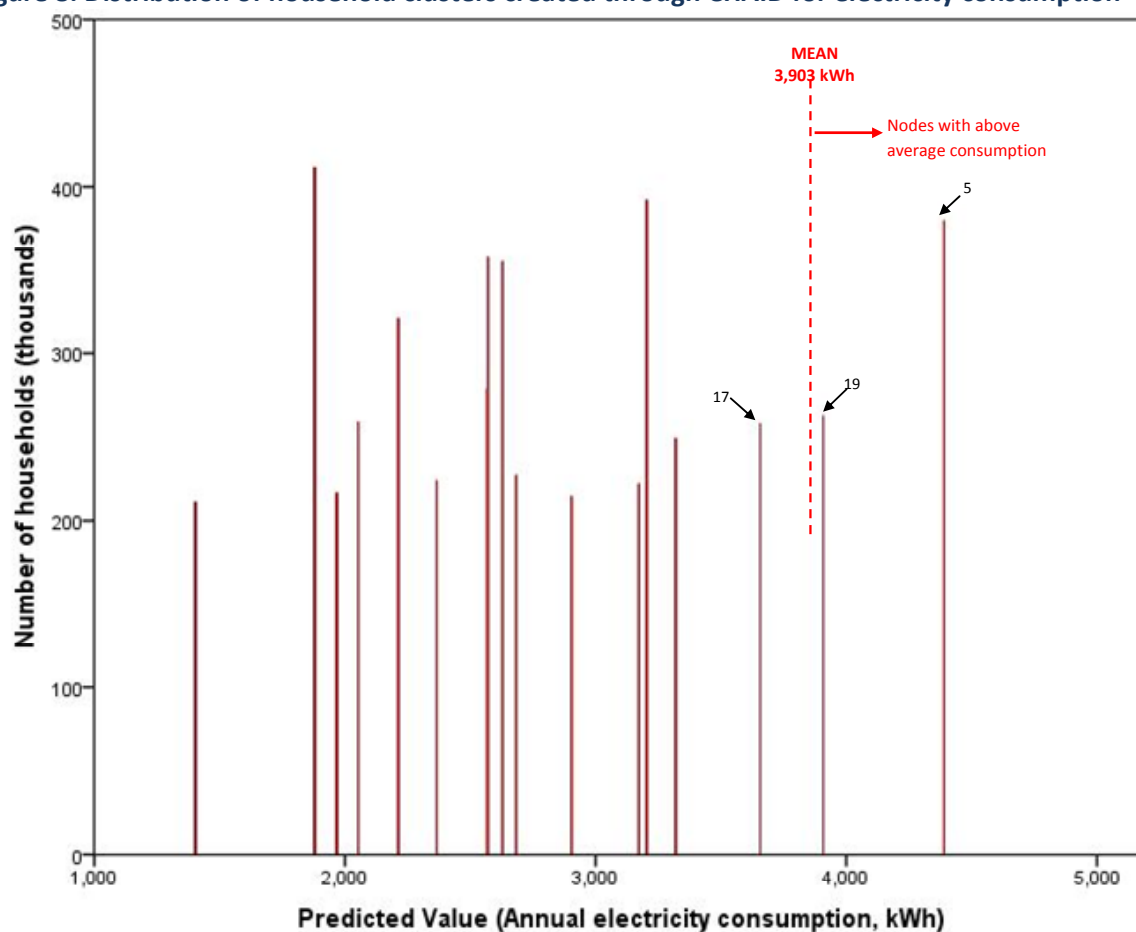
⁸ Priority Group is defined according to the CERT definition of vulnerable and low-income households, including those in receipt of eligible benefits and pensioners over the age of 70.

with the predicted electricity consumption on the x-axis and number of households (thousands) on the y-axis. As this shows, there are two nodes, totalling 642 thousand households (13% of all households in income deciles 1 and 2, Table 6) that have a (nodal) average electricity consumption (the predicted value) above the mean for the whole dataset (3,903 kWh). This count is lower than the number of households identified as having 'above average' consumption in the previous section, as the latter estimate uses case level consumption data, whilst CHAID uses a mean value of consumption for all cases in a node. One additional node (node 17, consisting of nearly 258 thousand households, shown in italics in Table 6) has a predicted consumption value above the median (3,426 kWh) for the dataset.

Table 6. Low income above average electricity consumption nodes

| Node ID | Number of households | % of all low income households | Average electricity consumption (kWh) |
|--------------|----------------------|--------------------------------|---------------------------------------|
| 5 | 379,811 | 7.8% | 4,390 |
| 19 | 262,231 | 5.4% | 3,908 |
| Total | 642,041 | 13.3% | |
| <i>(17</i> | <i>257,584</i> | <i>5.3%</i> | <i>3,657)</i> |

Figure 8. Distribution of household clusters created through CHAID for electricity consumption



Characteristics of high consuming 'low income' nodes

Cross-tabulating the nodes created in the CHAID analysis with socio-demographic variables in the EFS helps to identify the underlying drivers for high consumption among low income households. The discussion below identifies and characterises the nodes with above average electricity consumption. This shows that Nodes 5 and 19 - the highest consumers - resemble typical fuel poor households. The node with above median consumption is also summarised.

Node 5: Retired couples, fairly large houses, in rural areas, without gas supply (380 thousand households)

- Fairly large (70% with 5 or more rooms), detached (40%) or semi-detached (60%) houses in rural areas without a gas supply. Occupants are mostly retired couples without children (i.e. they may have children who have already left the home) who own their home outright (55%). No households have gas central heating; but instead have electric (36%) or oil (23%) central heating systems. 28% have no central heating system at all.

Node 19: Retired, elderly single adults, smaller properties with electric or no central heating (262 thousand households)

- Households are smaller than the previous node (61% with 4 or fewer rooms) and mostly terraced houses (48%) or flats (42%). Again the majority do not have a gas supply (65%, of which 60% are flats), despite being in urban areas (80%) and so have electric (54%) or no central heating (36%). Occupants are mainly single, elderly retired adults without children who own their property outright. The majority (62%) are not in receipt of means tested benefits, but 85% are Priority Group (74% over 70). Properties may be energy inefficient – the modelled insulation variables⁹ suggest 31% and 52% need virgin loft and cavity wall insulation respectively.

Node 17: Couples with children or multi-person households, in large houses with gas central heating (258 thousand households)

- 100% of households in this node do have a gas supply and gas central heating. Houses are fairly large (all five or more rooms), detached (26%) and semi-detached (36%) in urban areas. There are no single person households, but mainly working couples (nearing retirement age), some with children, who own their home with a mortgage (26%) or outright (53%); 100% of households are not receiving means-tested benefits; households have a higher than average number of household appliances¹⁰.

Characteristics of high consuming 'income poverty' nodes

Running CHAID on the income poverty subset (i.e. including all households with an income less than 60% of the median; n = 6,733,864) results in a different set of nodes. The results of the CHAID analysis on this dataset are presented in detail in the annex. The nodes identified with above mean and median electricity consumption (Table 7) are described below.

⁹ Previous work undertaken by CSE for DECC and eaga CT estimated levels of insulation in the EFS using a model developed on the EHCS. For more information please see: www.cse.org.uk/downloads/file/distributional_impacts_of_UK_climate_change_policies_june_2010.pdf

¹⁰ Number of appliances is based on data in the EFS dataset. With the exception of TVs, this is limited to information on whether an appliance is present in the house, rather than the number of each appliance.

Table 7. Nodes of households in income poverty with above average electricity consumption

| Node ID | Number of households | % of all households in income poverty | Average electricity consumption (kWh) |
|--------------|----------------------|---------------------------------------|---------------------------------------|
| 11 | 310,288 | 4.6% | 5,062 |
| 21 | 284,600 | 4.2% | 4,344 |
| 27 | 248,063 | 3.7% | 4,063 |
| 24 | 234,658 | 3.5% | 4,053 |
| Total | 1,077,609 | 16.0% | |
| (23 | 241,297 | 3.6% | 3,453) |

Node 11: Retired, single elderly adults, in smaller properties with electric central heating

- Dwellings are smaller than average (54% with four or fewer rooms), with a higher proportion of flats (38%). All households in this node have electric central heating, with over 80% not having a gas supply. Occupants are mostly retired single elderly adults, without children who own their property outright. The nature of the dwelling, being small properties, and in towns and semi-rural areas, suggests the high electricity consumption is the result of a reliance entirely on electricity for heating and hot water, and occupants being at home more (being retired). This is similar to node 19 in the 'low income' subset described above.

Node 21: Large family homes with gas central heating

- All households in this node have gas central heating. The high electricity consumption appears to be the result of dwelling type and size - all having six or more rooms and the majority being detached or semi-detached (65%). There is also relatively high occupancy, with all households having 2 or more adults (13% have three adults). The age structure suggests these adults are nearing retirement, or early-retirees with offspring still living at home. Dwellings may be energy inefficient with a predicted 53% and 45% needing top-up loft and cavity wall insulation respectively. This is a higher income node (42% in decile 3) with only 48% Priority Group. This node displays some similarities to node 17 in the 'low income' subset.

Node 27: Young, single-parent families in social rented, electrically-heated flats

- The dwelling type dominating this node is similar to node 11 above: Dwellings are small flats (72% have four rooms) with 100% electric central heating (87% do not have a gas supply). However, occupancy and tenure appears very different: this node consists entirely of rented accommodation, with 67% being social rented, and a higher proportion of young, (single parent) families. As with node 11, these households are in urban to semi-rural areas. This is a lower income node (45% are in income decile one, with an average annual income of £7,771); 86% are Priority Group, with 73% in receipt of means-tested benefits. This node identifies a group of low income high electricity consumers that was not identified in the previous CHAID analysis. As fuel prices rise, this group of households is becoming increasingly vulnerable to fuel poverty: the income profile of this group means that the increase in prices sees their proportion of income being spent on fuel bills creep closer to the 10% threshold.

Node 24: Empty-nesters in large, detached rural properties, without a gas supply.

- The average annual electricity consumption of households in this node is only 10kWh less than node 27 above. As above, households are without a gas supply, but otherwise they display few similarities: households in this node are large (59% with 6 or more rooms), detached (48%) and reliant on oil (54%) or solid fuel (12%) for central heating, or have no central heating (21%). It is a slightly higher income node, with 34% in decile 3. Households consist mainly of couples aged 55+, still working full time (21%) or retired (63%), who own their home outright (87%). All are in semi-rural and rural areas (78% in villages and hamlets). Properties may be energy inefficient, with an estimated 45% having solid walls and needing top-up, or full (20%) loft insulation, and 30% with a boiler more than 12 years old. Only 26% are in receipt of means tested benefits, but 68% are Priority Group. This node displays similarities to node 5 in the CHAID analysis of the low income subset.

Node 23: Retired urban dwellers, fairly large houses without central heating

- Mainly medium-sized (61% with 5 or 6 rooms), terraced houses (45%) in urban areas. Although the majority have a gas supply (72%), they do not have central heating (85%). Whilst it is not clear from the dataset how these households heat their home, there is evidence of low appliance use, suggesting electricity consumption may be pushed up by a reliance on plug-in electric heaters. Occupants are retired, single adults and couples (without children at home), aged 55+, who own their home outright (84%). Dwellings may be energy inefficient – relatively high proportions are estimated to have no loft insulation (27%) and solid walls (36%). Less than three quarters (73%) are Priority Group. This node is similar to node 24 above but in an urban environment.

3.2. Gas consumption

The dependent variable in this model is annual household gas consumption (in kWh). CHAID was run on the full 'low income' (deciles 1 and 2) dataset (n = 4,841,222) and on a filtered version to include only those low income households with a gas supply (n = 3,842,651). The models gave exactly the same results, with the former correctly identifying all households without a gas supply and separating these into their own nodes.

The predictor variables selected by the model (as run on the gas supplied households) as having a significant relationship with gas consumption are shown below.

Table 8. Predictor variables selected by the CHAID model for gas consumption

| | |
|----------------------------|----------------------------|
| • Tenure | • Age of HRP |
| • Rooms in accommodation | • Category of dwelling |
| • Government Office Region | • Employment status of HRP |

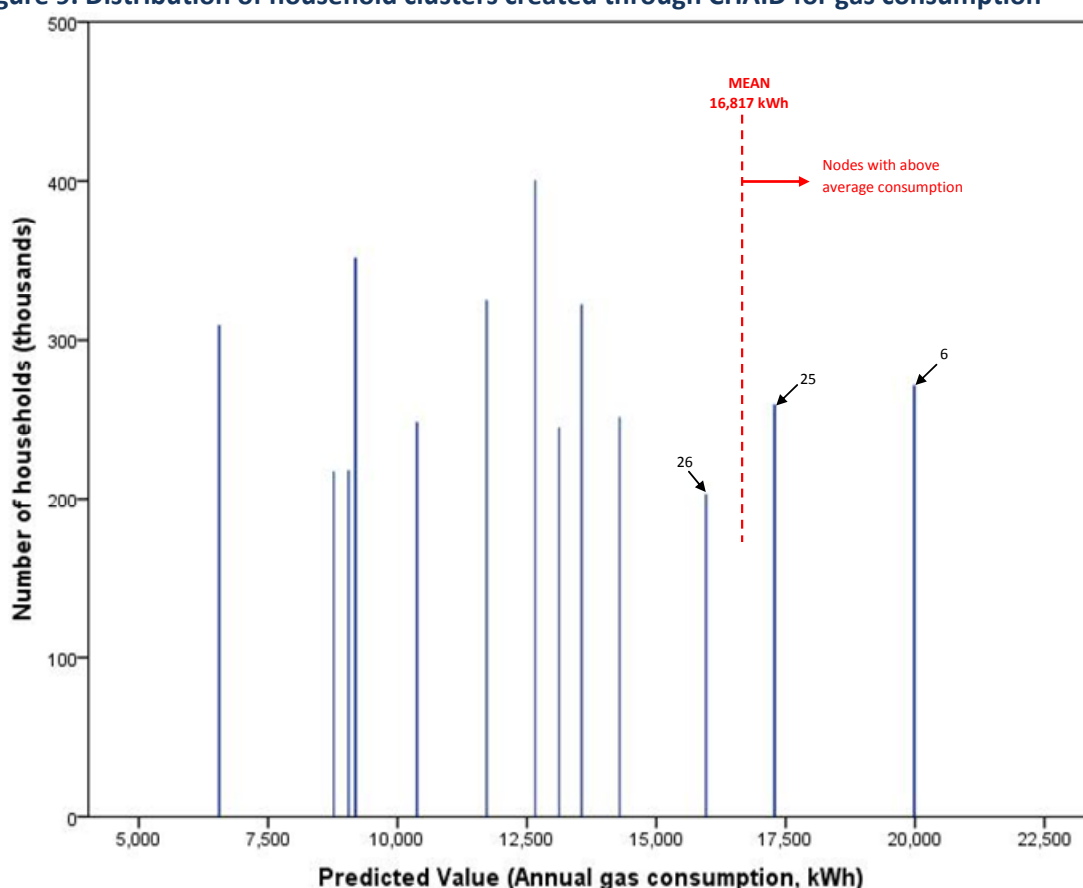
The CHAID model resulted in 14 nodes. The distribution of these nodes is shown on the histogram below, with the predicted gas consumption on the x-axis and number of households on the y-axis. There are two nodes, totalling 530 thousand households (14% of all low income households with a gas supply, Table 9) that have a (nodal) average gas consumption (the predicted value) above the

mean (for the 'gas-supplied') dataset (16,817 kWh). There is again one additional node, totalling 203 thousand households, with above median consumption (15,375 kWh). The characteristics of these nodes are described below. As this shows, nodes 6 and 25 – the highest consuming groups – display typical 'fuel poor' household characteristics.

Table 9. Low income above average gas consumption nodes

| Node ID | Number of households | % of all low income households | Average gas consumption (kWh) |
|--------------|----------------------|--------------------------------|-------------------------------|
| 6 | 271,004 | 7.1% | 19,984 |
| 25 | 258,949 | 6.7% | 17,285 |
| Total | 529,956 | 13.8% | |
| (26 | 202,908 | 5.3% | 15,960) |

Figure 9. Distribution of household clusters created through CHAID for gas consumption



Characteristics of high consuming 'low income' nodes

Node 6: Early-retirees, empty-nesters, in large houses (271 thousand households)

- Large (all 7 or more rooms), detached (41%) and semi detached (32%) houses with gas central heating. Houses are owned outright (78%) or with a mortgage (22%), in urban or fringe areas. Occupants are couples without children, either still working full time (14%) or retired (60%), being aged 55+. Compared to the low income dataset as a whole, these households receive relatively few benefits (27% compared to an overall 61% in receipt of

mean tested benefits). Houses may be poorly insulated with 48% and 47% predicted to need top-up loft and cavity wall insulation respectively.

Node 25: Single elderly, fairly large houses (259 thousand households)

- Medium-sized (all with 5 rooms), semi-detached (40%) and detached (24%) houses, with gas central heating, in urban and semi-rural areas (10% fringe, 6% village). Occupants are mainly single, retired (99%) and own their properties outright (94%), all being over 65 with no children in the house. This node is 91% Priority Group, but this is mainly due to age (86% are over 70, whereas only 37% claim means-tested benefits). Houses maybe poorly insulated with a predicted 21% and 59% requiring virgin and top-up loft insulation respectively.

Node 26: Elderly couples, large urban semi's (203 thousand households)

- This node is very similar to node 25 above, except houses are slightly larger (all with 6 rooms), but with fewer detached and more semi-detached in urban areas. As above occupants own their home outright, are retired (all over 65), and without children, but there are more couples than node 25. Again, houses may be energy inefficient with an estimated 32% and 47% requiring virgin and top-loft insulation respectively. Households are 90% Priority Group, with 82% being over 70.

Characteristics of high consuming 'income poverty' nodes

Running CHAID on the income poverty, gas supplied subset (i.e. including all households with an income less than 60% of the median and with a gas supply; n = 5,402,707) results in a different set of nodes. The results of the CHAID analysis on this dataset are presented in detail in the annex. The nodes identified with above mean and median gas consumption (Table 10) are described below. Here, nodes 36, 13 and 33 display typical characteristics of fuel poor households.

Table 10. Income poverty and above average gas consumption nodes

| Node ID | Number of households | % of all income poor households | Average gas consumption (kWh) |
|--------------|----------------------|---------------------------------|-------------------------------|
| 14 | 205,811 | 3.8% | 23,124 |
| 36 | 266,105 | 4.9% | 18,223 |
| 13 | 232,553 | 4.3% | 17,175 |
| Total | 704,469 | 13.0% | |
| (35) | 383,452 | 7.1% | 16,721 |
| (33) | 243,336 | 4.5% | 15,616 |

Node 14: Working families and multi-person households in large detached houses

- Large (all with 7 or more rooms) detached (41%) and semi-detached (34%) houses, in urban and town/fringe areas, with gas central heating. Occupants are a mix couples, families (9% have 2 children) and multi-person households (8% with three adults). The HRP is mainly between the ages of 45 and 64, and own their home outright (71%) or with a mortgage (29%). There is mixture of employed, not working and retired householders, with a higher proportion in full-time employment (20%) and fewer over the age of retirement (30%) compared to the income poverty subset overall. The age and working status is reflected by

the higher average income of this node (50% are in decile 3) and non-Priority Group status (54% being PG). Households also have a greater number of appliances, which may reflect higher incomes and occupancy rates. Properties may be energy inefficient with an estimated 53% and 47% needing top-up loft and cavity wall insulation respectively. This node represents a very different group of low income high gas consuming households compared to those identified in the previous CHAID model (not surprising as half the households in this node are not applicable to the previous CHAID analysis of low income households, with 50% being in decile 3). However, there are some similarities with node 21 in the income poverty electricity model. Again, this represents a group of low income households increasing at risk from fuel poverty with fuel price rises.

Node 36: Retired couples in fairly large, semi-detached urban houses

- Fairly large (all with 6 rooms), semi-detached houses, all with gas central heating, being mainly in urban areas (85%), with a high proportion (27%) in the South East. Occupants are couples without children at home, who own their property outright (80%). The majority are retired (67%), being over the age of 65 (66%). Despite being a higher income node (46% in decile 3 and average income over £10k), 70% are Priority Group. This node shows some similarities to node 26 and 6 in the 'low income' analysis above.

Node 13: Retired, single adults in large, detached and semi-detached houses

- This node consists of large (all 7 or more rooms), detached (38%) and semi-detached (36%) houses with gas central heating. All are occupied by single adults, who are mainly retired (73%), female (74%) and own their home outright (82%). Properties may be energy inefficient with 19%, 47% and 46% estimated to need full-loft, top-up loft and cavity wall insulation respectively. The combination of dwelling type (large houses) and inhabitants (single adults) suggests under-occupancy may be a real issue for these households (i.e. they have to heat more rooms than they actually need). This is similar to node 25 in the 'low income' CHAID model.

Node 35: Higher income, medium-sized semi-detached houses

- Medium sized (all with 5 rooms), semi-detached (45%) houses with gas central heating. Occupants are a mix of couples (37%) and single adults (62%), without children at home, and over 65 and retired (66%) or aged 55-64 and in full-time employment (16%). Properties are all owner occupied (owned outright (78%) or with a mortgage (23%)). This is a higher income node (with no households in decile 1; 51% in decile 3; and average income over £10k), but 67% are PG. Nearly two thirds are estimated to need top-up loft insulation. This is similar to node 36 above but with slightly smaller houses.

Node 33: Very low income, single retired in fairly large houses.

- This node displays similar characteristics to node 13 above (and therefore node 25 in the 'low income' CHAID analysis), only properties are smaller and lower income: 81% are in decile 1, (average income £5.5k), semi-detached (39%) and terraced (36%) houses with 5 or 6 rooms. Occupants are mainly single, retired, female adults, (without children at home) who own their home outright (77%) or with a mortgage (23%). Properties may be energy inefficient with 22% and 59% estimated to need full and top-up loft insulation respectively.

3.3. Combined consumption

The dependent variable in this CHAID model is annual household combined electricity and gas consumption. The analysis was run on the full 'low income' (deciles 1 and 2) subset (n = 4,841,222). The predictor variables selected by the model as having a significant relationship with combined household electricity and gas consumption are shown below.

Table 11. Predictor variables selected by the CHAID model for combined consumption

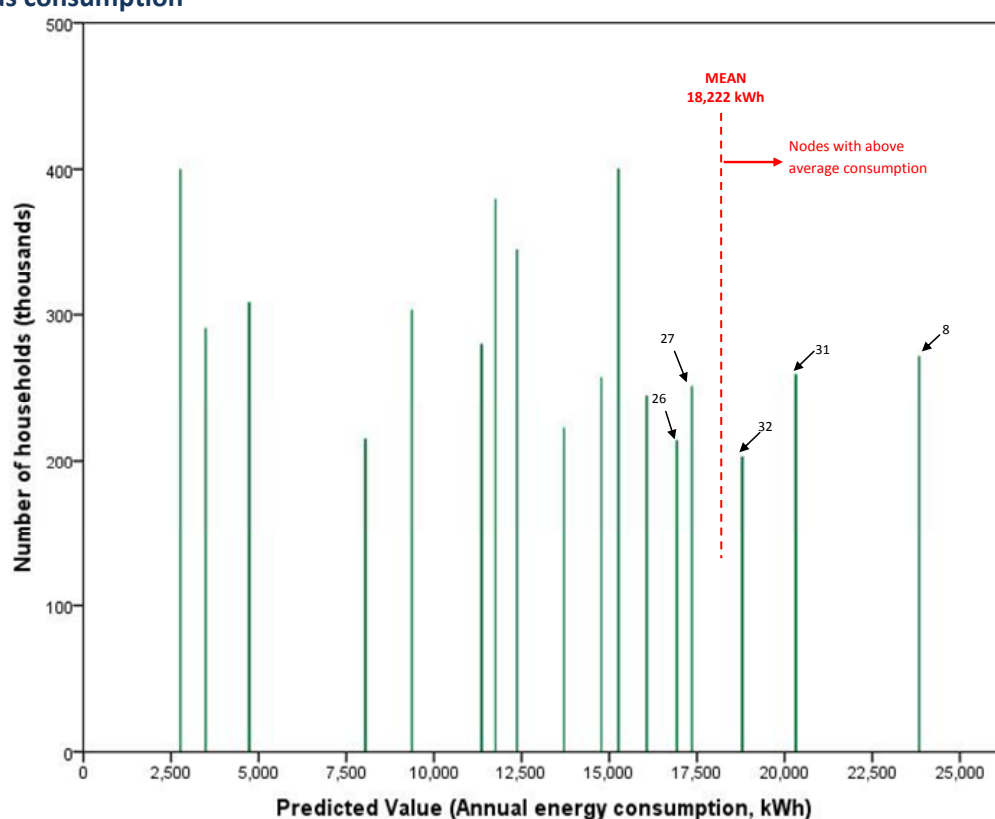
| | |
|--------------------------|------------------------|
| • Gas supply | • Govt. Office Region |
| • Tenure | • Category of dwelling |
| • Rooms in accommodation | • Central heating type |
| • Age of HRP | |

The CHAID model resulted in 17 nodes. The distribution of these nodes is shown on the histogram below, with the predicted combined fuel consumption on the x-axis and number of households on the y-axis. As this shows, there are three nodes, totalling 733 thousand households (15% of all low income households, Table 12) that have a (nodal) average combined consumption (the predicted value) above the mean for the whole dataset (18,222 kWh). A further two nodes (27 and 26) totalling about 565 thousand households, have a predicted combined consumption above the median (16,886 kWh). The characteristics of these nodes are described below.

Table 12. Low income above average combined fuel consumption nodes

| Node ID | Number of households | % of all low income households | Average electricity consumption (kWh) |
|--------------|----------------------|--------------------------------|---------------------------------------|
| 8 | 271,004 | 5.6% | 23,836 |
| 31 | 258,949 | 5.3% | 20,320 |
| 32 | 202,907 | 4.2% | 18,795 |
| Total | 732,864 | 15.1% | |
| (27 | 250,964 | 5.2% | 17,357) |
| (26 | 213,720 | 4.4% | 16,928) |

Figure 10. Distribution of household clusters created through CHAID for combined electricity and gas consumption



Characteristics of high consuming 'low income' nodes

The three high consuming nodes identified by CHAID in the low income subset display very similar characteristics to those identified in the gas CHAID model.

Node 8: Early-retirees, "empty-nesters", in large houses (271 thousand households)

- Large detached (41%) and semi-detached (32%) houses with 7 or more rooms and gas central heating. A high proportion is in the South East (19%). Occupants are couples who own their property outright or with a mortgage, living in urban and fringe areas, either still working full time (14%) or retired (60%), the majority being 55+, without children at home. Properties may be poorly insulated with a predicted 18%, 48%, and 47% requiring virgin loft, top-up loft and cavity wall insulation respectively. Compared to the low income subset as a whole, take-up of (means-tested) benefits in this group is low (27%), and only 60% are Priority Group. These households have a higher number of household appliances compared to the low income subset overall.

Node 31 and 32: Single elderly in large houses (462 thousand households)

- These two nodes display very similar characteristics: they live in fairly large semi-detached houses with 5 or 6 rooms, with gas central heating, again predominantly in the South East (23%). Occupants are mainly single adults who own their home outright and are retired (99%). All are over the age of 65 with no children at home. The average income of these nodes is greater than the average for the low income subset. Households may be poorly

insulated with a predicted average 26% and 53% needing virgin and top-up loft across the two nodes. Take-up of means tested benefits is low, but these nodes are 90% Priority Group.

The two additional nodes with above median consumption exhibit quite different qualities to those described above:

Node 27: Working age couples in fairly large houses (251 thousand households)

- Fairly large (5 or 6 rooms) terraced and semi-detached houses with gas central heating; occupants are mainly couples, some with children, who own their home outright or with a mortgage, in employment (27% full time) or not working (41%), all being under the age of retirement (mainly aged 45 – 64); households have a higher than average number of appliances, and are not in receipt of means-tested benefits and are non-Priority Group.

Node 26: Young families in local authority housing (214 thousand households)

- Fairly large (5 or more rooms) terraced and semi-detached houses with gas central heating; occupants are mainly young families (20% with HRP aged 25-34 and 39% have children) who are 'not working', in Local Authority rented accommodation in urban areas; they are mainly Priority Group due to benefits take-up.

Characteristics of high consuming 'income poverty' nodes

Running CHAID on the income poverty subset (i.e. including all households with an income less than 60% of the median; n = 6,733,864, see section 2.1) results in a different set of nodes. The results of the CHAID analysis on this dataset are presented in detail in Annex 2. The nodes identified with above mean and median combined electricity and gas consumption (Table 13) are described below.

Table 13. Low income above average combined fuel consumption nodes

| Node ID | Number of households | % of all low income households | Average electricity consumption (kWh) |
|--------------|----------------------|--------------------------------|---------------------------------------|
| 18 | 205,814 | 3.1% | 27,742 |
| 44 | 313,738 | 4.7% | 21,126 |
| 17 | 232,553 | 3.5% | 20,528 |
| 48 | 220,662 | 3.3% | 19,313 |
| 47 | 358,488 | 5.3% | 19,132 |
| Total | 1,331,255 | 19.8% | |
| (45) | 218,695 | 3.2% | 18,134) |
| (31) | 202,881 | 3.0% | 17,566) |

As with the 'low income' analysis, nodes with the highest combined electricity and gas consumption in the income poverty subset display very similar characteristics to the highest gas consuming nodes.

Node 18: Couples with children and HMOs in large, detached, gas centrally heated houses

- This node consists of large (all 7 or more rooms), detached (41%) and semi-detached (34%), gas centrally heated households, in urban and town/fringe areas. There are no single adult households: occupants are couples, some with children at home, or multi-person

households. A high proportion (relative to the income poverty subset overall) are working full-time (20%), the majority being working age (40% over 65). Homes are owned outright (71%) or with a mortgage (29%) and are higher income (50% in decile 3). Properties may be energy inefficient with 53% and 47% estimated to need top-up loft and cavity wall insulation respectively. The higher income and multi-person status is reflected in a higher number of household appliances. Just over half the households in this node are Priority Group. There are some similarities with node 26 in the low income CHAID model, but as 50% are in income decile 3 (and are therefore not applicable to the previous analysis), this largely represents a set of newly identified 'low income' high consuming households compared with the quintile 1 only analysis.

Node 44: Retired couples, 'empty nesters' in fairly large, semi-detached urban houses

- Fairly large (all with 5 or 6 rooms), semi-detached (46%) houses, all with gas central heating, in urban areas (85%), with a high proportion in the South East. Occupants are couples without children at home, who own their property outright (75%). The majority are retired (60%), or working full time (17%). Despite being a higher income node (54% in decile 3 and average income over £10k), 67% are Priority Group (45% have a resident over 70). Again, as over half of households in this node are in decile 3, there is not a comparable node in the previous CHAID analysis. It is however similar to node 36 in the gas income poverty CHAID model above.

Nodes 17, 48 and 47: Retired, single adults in large, detached and semi-detached houses.

- These three nodes display very similar characteristics: they are all single adult households, the majority being retired and female, who own their home outright. Properties are gas centrally heated, and mainly semi-detached and fairly large, with rooms ranging from 5 (node 47) to 7+ (node 17), which suggests under-occupancy may be an issue for many. There is generally low take-up of benefits in these group (28% on average) but around 70% are PG. These nodes show some similarities to nodes 31 and 32 above (and are very similar to node 13 in the gas income poverty CHAID model).

Node 45: Higher income couples without children, nearing retirement, in fairly large gas centrally heated houses.

- Fairly large (all with 5 or 6 rooms), semi-detached (44%) and detached (20%), all with gas central heating. A high proportion is in the NE and NW (57%). Properties are all owner occupied (78% outright, 22% with mortgage) mainly by couples without children, nearing retirement, with 21% still working full-time. This is a higher income node with 53% in decile 3, and as such benefits take-up, and PG status is low (62% Priority Group).

Node 31: Younger, single parent families not working, in fairly large semi-detached social rented housing

- This represents a particularly low income cluster (66% in decile 1, average annual income £6k) of fairly large (mostly 5 or 6 rooms), semi-detached houses with gas central heating. Occupancy rates are high, consisting mainly of young (34% 25 – 44), single parent families, who are not working. All are in rented accommodation, with 72% being LA or HA. There is high take-up of benefits (87% in receipt of means-tested) and 91% are PG. This is similar to node 26 in the 'low income' combined consumption CHAID model.

4. Targeting low income high consumers

The CHAID analysis described in section 3 has identified some of the key defining characteristics of low income high consuming households, based on the EFS dataset. Using two different definitions to identify 'poor' households has helped to identify different groups of high consuming and potentially vulnerable households. Successful targeting of these households depends on the potential to identify them amongst all low income and all high consuming households. This section therefore further explores the differences between these potentially vulnerable groups and the rest of the population. In particular, the applicability of targeting criteria based on age and Priority Group status is considered.

The discussion below focuses on the analysis of households in income deciles 1 and 2 only – referred to as the 'low income' CHAID. However, the results of the analysis using the income poverty definition are also drawn upon – referred to as the 'income poverty' CHAID.

High electricity consumers

Looking at electricity consumption only and the 'low income' (deciles 1 and 2) CHAID results, the analysis identifies households without a gas supply and reliant on electricity for heating as a clear defining characteristic of 'low income' high electricity consumption. However, two further nodes that also rely on electricity for heating were also identified in the CHAID model but these do not have high electricity consumption. The key differences between these nodes and the high consuming nodes identified are shown below (Table 14). Whilst all are reliant on electricity for heating, the high consumers are notably larger houses with older occupants.

Table 14. Characteristics of low income households (income deciles 1 & 2 only) reliant on electricity for heating

| | High consumers | Low consumers |
|------------------------------------|--------------------------------|--------------------------------|
| Household type and size | Larger houses | Smaller flats |
| Tenure | Owner occupiers | LA/HA tenants |
| Rurality | Highest consumer is rural | Urban |
| Occupancy | Single adults without children | Single adults without children |
| Age & employment status | Over 65, retired | More working age occupants |

The CHAID analysis of households in income poverty (defined according to the 60% of median income threshold) identified a similar set of high electricity consuming households to the low income (decile 1 and 2) analysis, whereby high electricity consumption appears driven by a reliance on electricity for heating, or larger properties, or both. However, the income poverty electricity CHAID analysis identified an additional cluster of high consumers, who are considered increasingly at risk from fuel poverty - *young adults living in social rented, electrically-heated flats, with children* (see section 3.1).

High gas/ combined consumers

For gas and combined electricity and gas consumption, larger properties with retired owner occupiers dominate the high consuming low income nodes identified in CHAID. The analysis below

further explores the differences between the high consuming groups identified through the low income (deciles 1 & 2 only) CHAID (with above mean and above median nodes differentiated) and the remaining (low income and whole) population (Figure 11 and Table 15). Full summary statistics for each node (including the income poverty analysis) is included in annex 3.

Figure 11. Characteristics of low income high consuming households (identified through CHAID) compared to all low income households and the whole population



Table 15. Dominant characteristics of high consuming CHAID groups compared to all low income households and the whole population

| | CHAID NODES | | | | All low income | All HHs |
|--------------------------------------|------------------------|--------------------------|-----------------------|-------------------------|----------------|--------------|
| | Low income > elec mean | Low income > elec median | Low income > E&G mean | Low income > E&G median | | |
| Rurality | Urban/Rural | Urban | Urban | Urban | Urban | Urban |
| Built form | Semi/detached | Semi/terrace | Detached/semi | Terrace/semi | Terrace/flats | Semi/terrace |
| No. rooms¹¹ (mean) | 5 | 6 | 7 | 5 | 5 | 6 |
| Tenure | OO | Owned (OO/M) | OO | Mix | LA & HA | Mortgage |
| Employment status | Retired | Mix | Retired | Not working | Retired | Full time |
| Age (mean) | 68 | 55 | 71 | 50 | 59 | 52 |
| No. adults (mean) | 1 | 2 | 1 | 1 | 1 | 2 |
| No. children (mean) | 0 | 0 | 0 | 0 | 0 | 1 |
| Claiming benefits | 50/50 | No | No | Yes | Yes | No |
| Over 70 | Yes | No | Yes | No | No | No |

Single, retired owner occupiers, in relatively large (i.e. under-occupied) houses appear as a key group of low income high consumers¹². However, energy suppliers are limited in the information available to them about households. Adhering to these limitations, the analysis below explores the applicability of an over 70 and Priority Group criteria in identifying low income high consumers.

Analysis of households over 70 and Priority Group in the EFS dataset (see summary statistics in Annex Table 1 for totals) shows that:

- ⇒ 37% of all over 70 households are 'low income' (in deciles 1 or 2)
- ⇒ 39% of all 'low income' households are over 70
- ⇒ 32% of the Priority Group is 'low income'
- ⇒ 81% of 'low income' households are Priority Group

Taking the raw EFS energy consumption data (rather than the CHAID results) shows that low income over 70 households account for between 35-41% of all 'low income above average' consumers (depending on the fuel type – i.e. electricity only, gas only or both fuels combined). Low income Priority Group households account for 76-78% of all 'low income above average' consumers (see Annex Table 2 for figures).

- ⇒ 40% of all 'low income above average' consumption households are over 70
- ⇒ 76% of all 'low income above average' consumption households are Priority Group

However, the numbers of low income households within the 'above average over 70' or 'above average Priority Group' subsets are proportionally less.

- ⇒ 25% of all Over 70 above average energy consumption households are low income
- ⇒ 19% of Priority Group households with above average energy consumption are low income

¹¹ The EFS records number of habitable rooms, rather than number of bedrooms.

¹² Where the maximum household income according to the definitions applied in this analysis is £13,090.

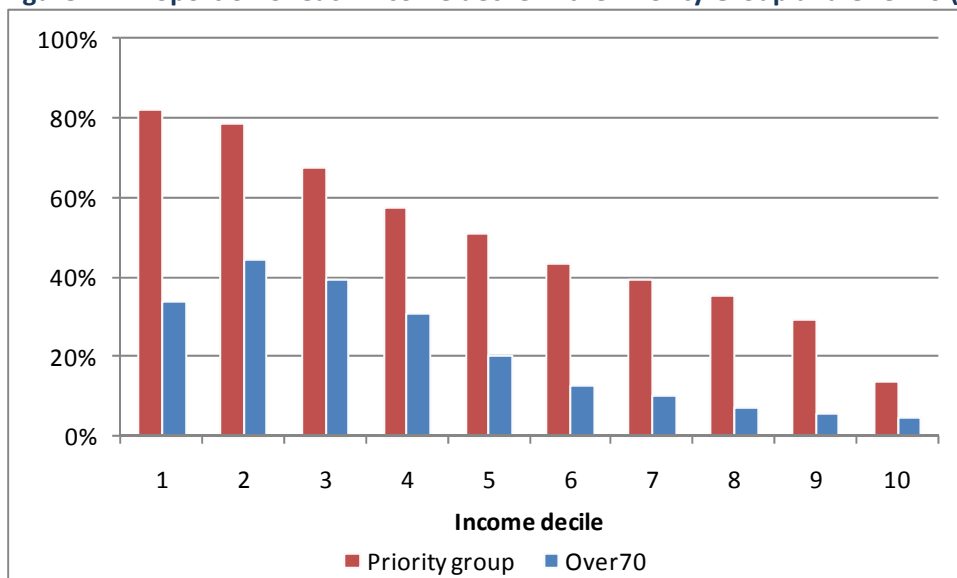
Targeting Priority Group households with above average energy consumption (some 5 million households in total) would capture over 900,000 of the 'low income high consumption' subset of 1.2 million households (i.e. hits 76% of the target audience). However, this approach would also encompass some 4 million households in income deciles 3 and above, of which 3 million (72%) are in deciles 5 and above.

Focusing only on the over 70s with above average energy consumption on the other hand (some 1.9 million households) would capture less than half of the 'low income high consumption' subset (488,000 out of the 1.2 million), with 1.4 million of the households targeted (75%) in income deciles 3 and above, of which 810,000 (56%) are in deciles 5 and above.

To summarise, based on analysis of the EFS dataset, targeting support at Priority Group households with above average energy consumption hits three quarters of all 'low income high consumers', but with the trade-off that an additional 3 million higher income households (with above average consumption) are also 'hit'. Whereas targeting over 70s with above average energy consumption significantly reduces the number of higher income households 'hit' by the targeting method, it also reduces the hit rate for low income high consumers to 40%.

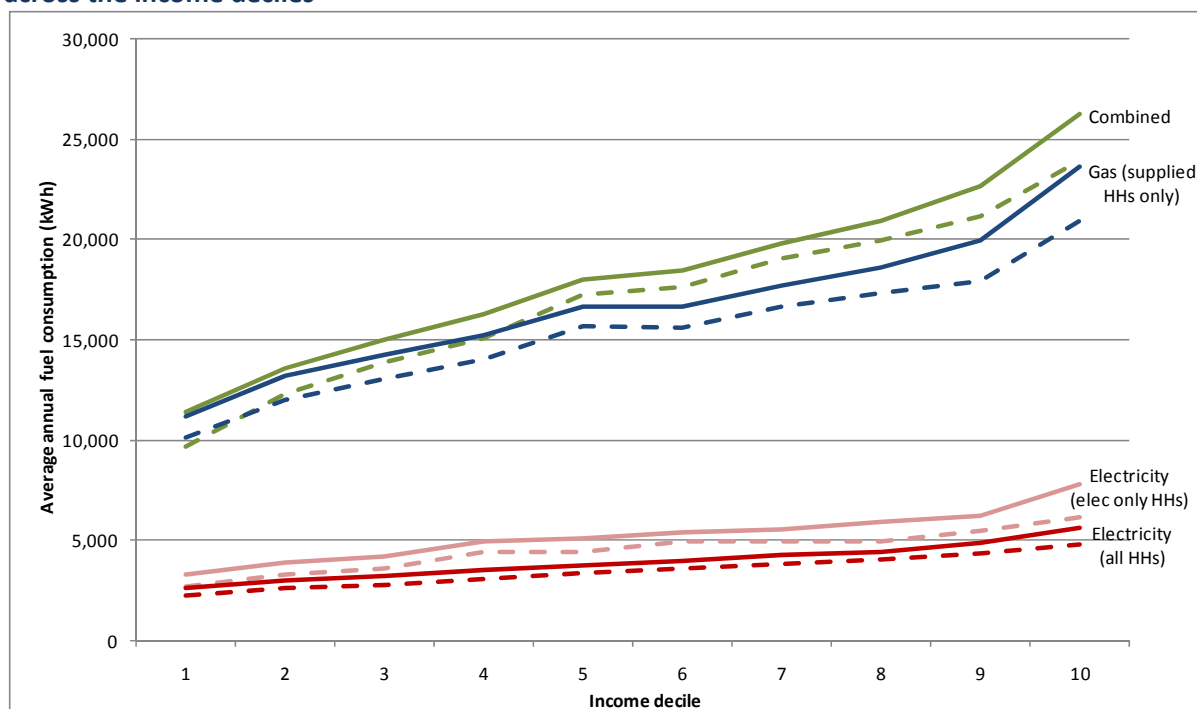
The inefficiency of the targeting approaches discussed above relates back to using Priority Group or Over 70s as a proxy for low income (Figure 12).

Figure 12. Proportion of each income decile in the Priority Group and Over 70 (based on EFS data)

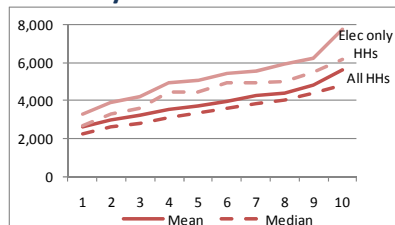


Annex 1 Summary statistics

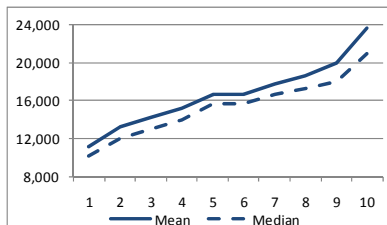
Annex Figure 1. Comparison of mean (solid lines) and median (dashed lines) fuel consumption across the income deciles



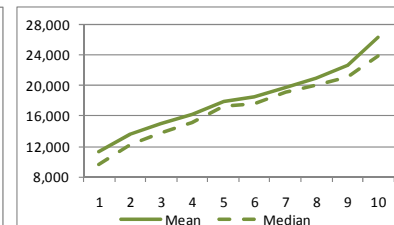
Electricity:



Gas:



Combined:



Annex Table 1. Summary statistics: EFS households over 70, Priority Group and low income (thousands)

| | |
|--|--------|
| Total over 70 | 5,058 |
| Total Priority Group | 12,061 |
| Total 'low income' (deciles 1 and 2) | 4,841 |
| Total over 70 'low income' | 1,889 |
| Total Priority Group 'low income' | 3,899 |
| Total in 'income poverty' | 6,734 |
| Total over 70 in 'income poverty' | 2,648 |
| Total Priority Group in 'income poverty' | 5,196 |

Annex Table 2. Summary statistics: EFS households with above mean consumption (thousands)

| | Elec. | Gas | Elec. & Gas |
|---|--------------|--------------|--------------|
| Total above mean households | 10,036 | 9,051 | 10,949 |
| Total 'low income'¹³, above mean households | 1,139 | 1,006 | 1,224 |
| Total in 'income poverty' ¹⁴ , above mean households | 1,663 | 1,527 | 1,867 |
| Total over 70, above mean households | 1,576 | 1,632 | 1,937 |
| Total Priority Group above mean households | 4,530 | 4,101 | 5,001 |
| Total 'low income', over 70, above mean households | 400 | 413 | 488 |
| Total 'low income', Priority Group, above mean households | 884 | 767 | 927 |
| Total 'income poverty', over 70, above mean households | 598 | 625 | 744 |
| Total 'income poverty', Priority Group, above mean households | 1,243 | 1,131 | 1,370 |

¹³ Indicates the target group: households in income deciles 1 and 2 with above mean energy consumption.

¹⁴ Using income poverty definition of annual household income less than 60% of the median.

Annex 2 CHAID analysis of 'income poverty' subset

The CHAID analysis presented in the main report is based on the 'low income' subset (households in income decile 1 and 2 only) and identifies clusters of households with above average electricity, gas and combined consumption. For comparison, CHAID was also then run on a subset of the EFS data to include those households in 'income poverty' according to the common definition (an annual household income of less than 60% of the median for the survey year). Applying this definition captures some households in income decile 3, as well as all those in deciles 1 and 2. The results of the CHAID analysis (for electricity, gas and combined consumption respectively) on this group of households are reported here.

Electricity consumption

The dependent variable in this CHAID model is annual household electricity consumption (in kWh). The predictor variables selected by the model as having a significant relationship with electricity consumption are shown below.

Annex Table 3. Predictor variables selected by the CHAID model for electricity consumption on the 'income poverty' subset

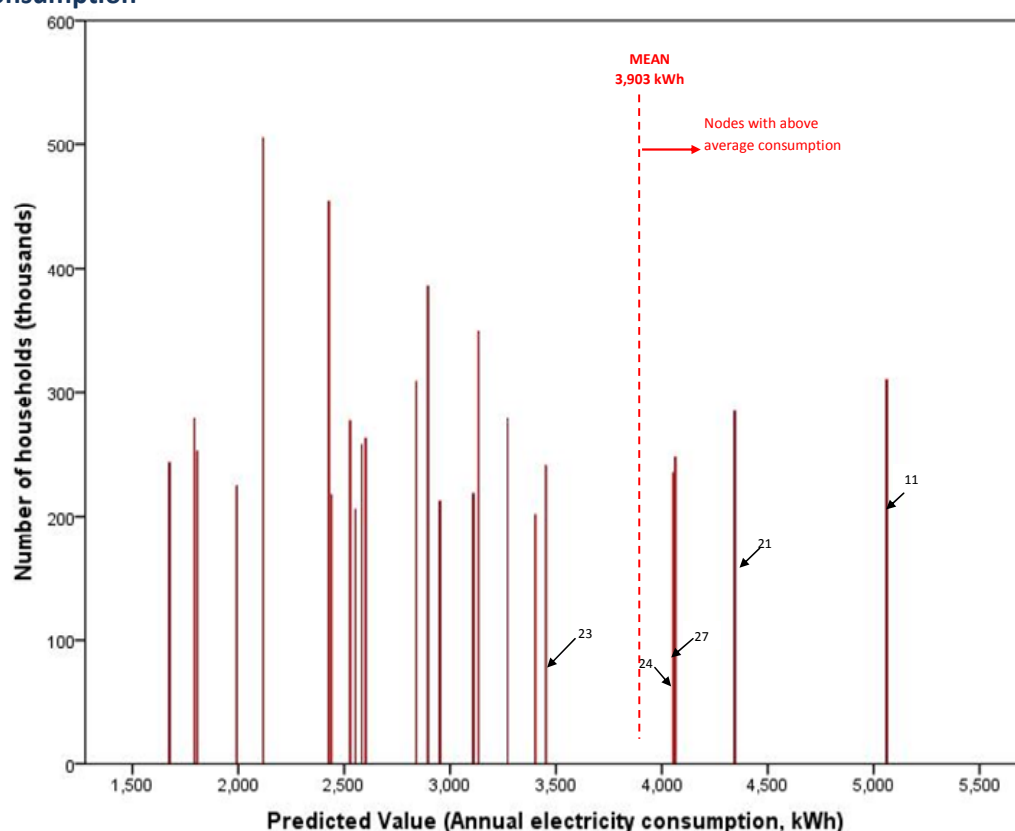
| | |
|--------------------------|--------------------------------------|
| • Central heating type | • Annual household disposable income |
| • Rooms in accommodation | • Sex of HRP |
| • Tenure | • Number of adults |
| • Age of HRP | • Employment status of HRP |
| • Govt. Office Region | • Rurality |

The CHAID model resulted in 24 nodes. The distribution of these nodes is shown on the histogram below, with the predicted electricity consumption on the x-axis and number of households (thousands) on the y-axis. As this shows, there are four nodes, totalling 1.08m households (16% of all 'income poverty' households, annex table 4) that have a (nodal) average electricity consumption (the predicted value) above the mean for the whole dataset (3,903 kWh). This count is lower than the number of households identified as having 'above average' consumption in section 2.3 (n = 1.66m), as the latter estimate uses case level consumption data, whilst CHAID uses a mean value of consumption for all cases in a node. One additional node (node 23, consisting of 241 thousand households, shown in italics in annex table 4) has a predicted consumption value above the median (3,426 kWh) for the dataset. The characteristics of these households are described in the main report (section 3.1)

Annex Table 4. Nodes of households in income poverty with above average electricity consumption

| Node ID | Number of households | % of all households in income poverty | Average electricity consumption (kWh) |
|-------------|----------------------|---------------------------------------|---------------------------------------|
| 11 | 310,288 | 4.6% | 5,062 |
| 21 | 284,600 | 4.2% | 4,344 |
| 27 | 248,063 | 3.7% | 4,063 |
| 24 | 234,658 | 3.5% | 4,053 |
| Total | 1,077,609 | 16.0% | |
| <i>(23)</i> | <i>241,297</i> | <i>3.6%</i> | <i>3,453</i> |

Annex Figure 2. Distribution of household clusters created through CHAID for electricity consumption



Gas consumption

The dependent variable in this model is annual household gas consumption (in kWh). Consistent with the analysis of 'low income' households, CHAID was run on the dataset of households in income poverty with a gas supply (n = 5,402,707). The predictor variables selected by the model as having a significant relationship with gas consumption are shown below.

Annex Table 5. Predictor variables selected by the CHAID model for gas consumption

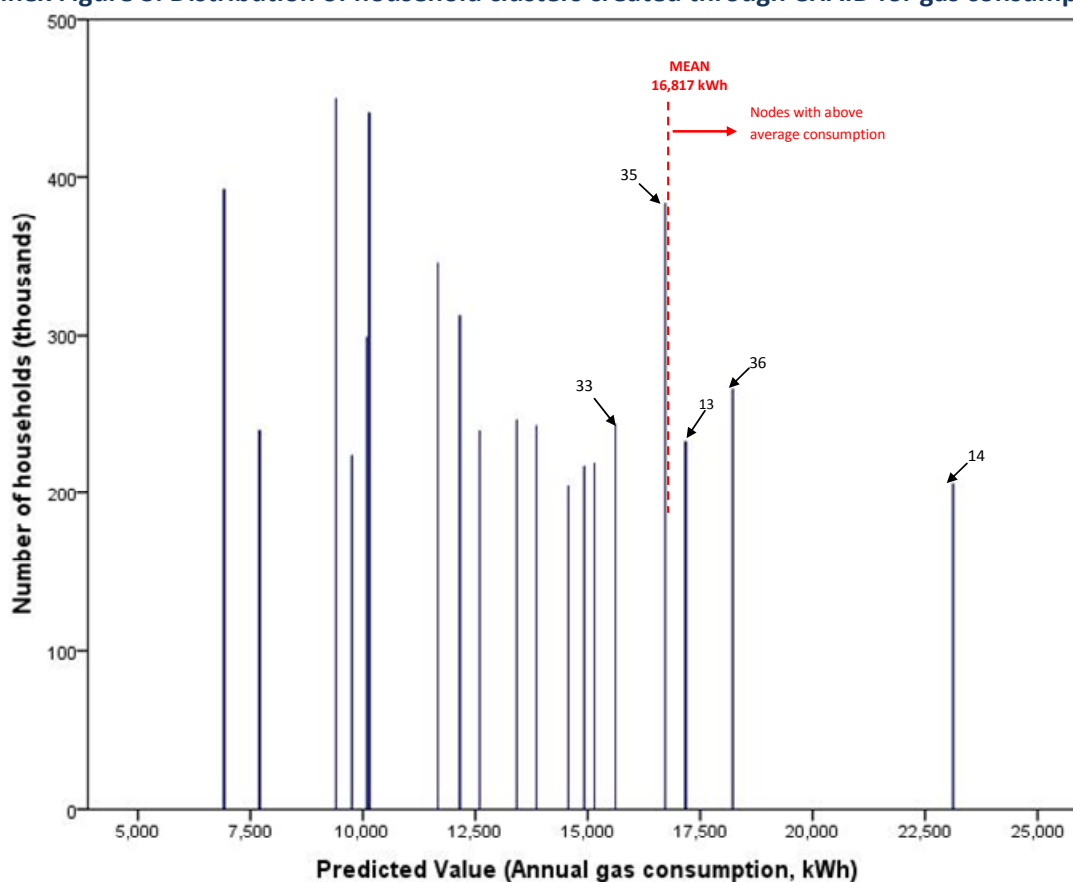
| | |
|----------------------------|----------------------------|
| • Tenure | • Sex of HRP |
| • Rooms in accommodation | • Category of dwelling |
| • Government Office Region | • Employment status of HRP |
| • Central heating type | • Annual disposable income |
| • Number of adults | |

The CHAID model resulted in 19 nodes. The distribution of these nodes is shown on the histogram below, with the predicted gas consumption on the x-axis and number of households on the y-axis. There are three nodes, totalling 704 thousand households (13% of all low income households with a gas supply, table 6) that have a (nodal) average gas consumption (the predicted value) above the mean (for the 'gas-supplied' dataset (16,817 kWh). There are two additional nodes, totalling 627 thousand households, with above median consumption (15,375 kWh). The characteristics of these nodes are described in the main report (section 3.2).

Annex Table 6. Income poverty and above average gas consumption nodes

| Node ID | Number of households | % of all income poor households | Average gas consumption (kWh) |
|--------------|----------------------|---------------------------------|-------------------------------|
| 14 | 205,811 | 3.8% | 23,124 |
| 36 | 266,105 | 4.9% | 18,223 |
| 13 | 232,553 | 4.3% | 17,175 |
| Total | 704,469 | 13.0% | |
| (35 | 383,452 | 7.1% | 16,721) |
| (33 | 243,336 | 4.5% | 15,616) |

Annex Figure 3. Distribution of household clusters created through CHAID for gas consumption



Combined consumption

The dependent variable in this CHAID model is annual household combined electricity and gas consumption (in kWh). The predictor variables selected by the model as having a significant relationship with combined consumption for the income poverty subset are shown below.

Annex Table 7. Predictor variables selected by the CHAID model for combined consumption

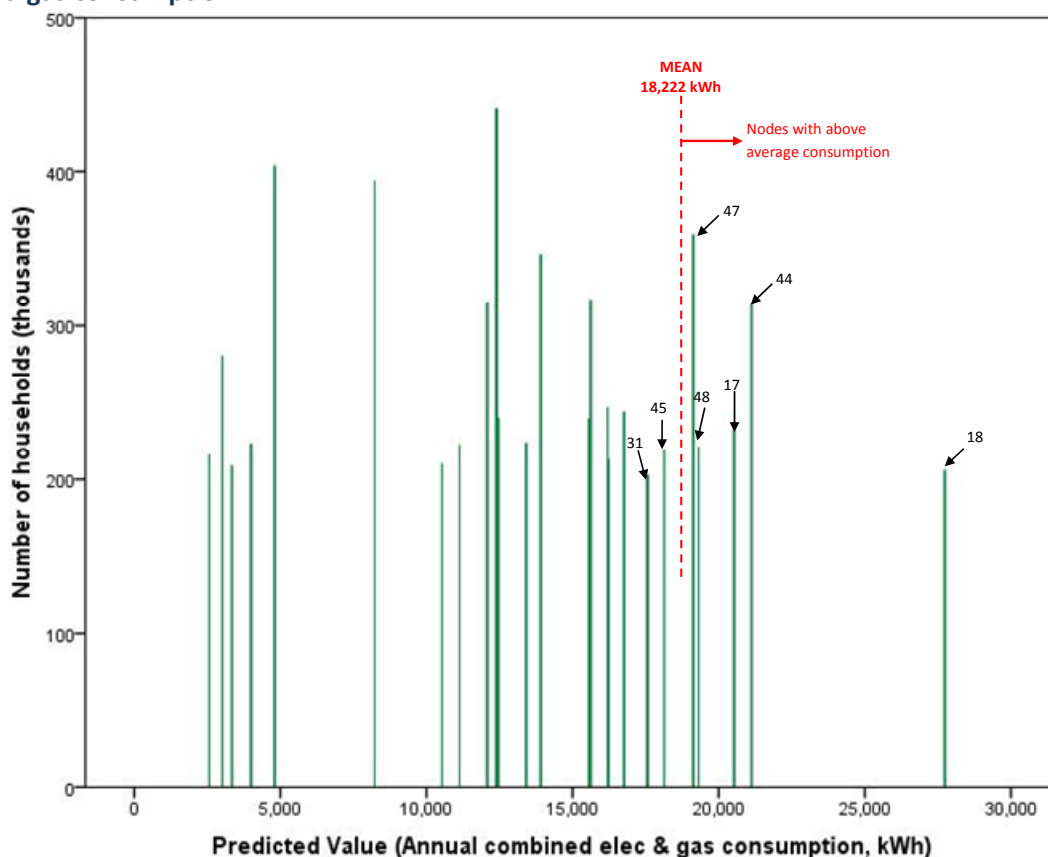
| | |
|--|---|
| <ul style="list-style-type: none"> • Gas supply • Tenure • Rooms in accommodation • Sex of HRP • Employment status of HRP | <ul style="list-style-type: none"> • Govt. Office Region • Category of dwelling • Central heating type • Number of adults • Annual disposable household income |
|--|---|

The CHAID model resulted in 25 terminal nodes. The distribution of these nodes is shown on the histogram below, with the predicted combined fuel consumption on the x-axis and number of households on the y-axis. As this shows, there are five nodes, totalling 1.33 million households (20% of all households in income poverty, table 8) that have a (nodal) average combined consumption (the predicted value) above the mean for the whole dataset (18,222 kWh). A further two nodes totalling about 422 thousand households, have a predicted combined consumption above the median (16,886 kWh). The characteristics of these nodes are described in the main report (section 3.3).

Annex Table 8. Low income above average combined fuel consumption nodes

| Node ID | Number of households | % of all low income households | Average electricity consumption (kWh) |
|--------------|----------------------|--------------------------------|---------------------------------------|
| 18 | 205,814 | 3.1% | 27,742 |
| 44 | 313,738 | 4.7% | 21,126 |
| 17 | 232,553 | 3.5% | 20,528 |
| 48 | 220,662 | 3.3% | 19,313 |
| 47 | 358,488 | 5.3% | 19,132 |
| Total | 1,331,255 | 19.8% | |
| (45) | 218,695 | 3.2% | 18,134 |
| (31) | 202,881 | 3.0% | 17,566 |

Annex Figure 4. Distribution of household clusters created through CHAID for combined electricity and gas consumption



Annex 3 Summary of high consuming nodes

Annex Table 9. Dominant characteristics of highest consuming electricity nodes compared to all low income and all households¹⁵.

| | All HHs | Deciles 1 & 2 | Node Identifier – Households in ‘income poverty’ | | | | | Node Identifier – ‘Low income’ HHs | | |
|-------------------------------|-----------|-------------------|--|-----------------------|---------------------|-------------------|---------------------------|------------------------------------|-------------------|--------------------------|
| | | | 11 | 21 | 27 | 24 | 23 | 5 | 19 | 17 |
| No. households (000s) | 24,207 | 4,841 | 310 | 285 | 248 | 235 | <i>241</i> | 380 | 262 | 258 |
| % of population | 100.0% | 20.0% | 1.3% | 1.2% | 1.0% | 1.0% | <i>1.0%</i> | 1.6% | 1.1% | 1.1% |
| Mean Electricity (kWh) | 3,903 | 2,788 | 5,062 | 4,344 | 4,063 | 4,053 | <i>3,453</i> | 4,390 | 3,908 | <i>3,657</i> |
| Mean Gas (kWh) | 16,817 | 12,211 | 1,494 | 19,680 | 1,248 | 1,375 | <i>7,479</i> | 2,701 | 3,585 | <i>19,044</i> |
| Mean Combined (kWh) | 18,222 | 12,482 | 6,556 | 24,024 | 5,311 | 5,427 | <i>10,932</i> | 7,091 | 7,493 | <i>22,701</i> |
| Rurality | Urban | Urban | Urban | Urban | Mix | Rural | <i>Urban</i> | Rural | Urban | <i>Urban</i> |
| Central heating | Gas | Gas | Electric | Gas | Electric | Oil / none | <i>None</i> | Electric/ none/ oil | Electric/ none | <i>Gas</i> |
| Built form | Semi | Flat / terrace | Flat | Semi | Flat | Detached | <i>Terrace</i> | Semi | Semi/ detached | <i>Terrace/ Flat</i> |
| Number of rooms (mean) | 6 | 5 | 5 | 7 | 4 | 6 | 5 | 5 | 4 | 6 |
| Tenure | Mortgage | SOC rented | Owned outright | Private sector mix | Rented (SOC/PRS) | Owned outright | <i>Owned outright</i> | Mix | Owned outright | <i>OO/ mortgage</i> |
| Employment status | Full time | Retired / NW | Retired | Not working | Retired/ NW | Retired | <i>Retired</i> | Retired | Retired | <i>NW/ working</i> |
| Age of HRP (mean) | 52 | 59 | 69 | 51 | 54 | 67 | 68 | 66 | 71 | 55 |
| No. of adults (mean) | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| No. of children (mean) | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Occupant over 70 | No | No | Yes | No | No | Yes | <i>Yes</i> | Yes | Yes | <i>No</i> |
| Claiming benefits | No | Yes | No | No | Yes | No | <i>No</i> | 50-50 | No | <i>No</i> |

SOC = social rented; PRS = private rented; NW = not working (under minimum state retirement age, but not registered unemployed)

¹⁵ Figures in italics show above median nodes.

Annex Table 10. Characteristics of highest consuming nodes (electricity and gas combined consumption) compared to all low income and all households.

| | All HHs | Deciles 1 & 2 | Node Identifier – Households in 'income poverty' | | | | | | | Node Identifier – 'Low income' HHs | | | | |
|-------------------------------|-----------|-------------------|--|-------------------|-----------------------|-------------------|-------------------|-------------------|----------------------|------------------------------------|-------------------|-------------------|-----------------|----------------|
| | | | 18 | 44 | 17 | 48 | 47 | 45 | 31 | 8 | 31 | 32 | 27 | 26 |
| No. households (000s) | 24,207 | 4,841 | 206 | 314 | 233 | 221 | 358 | 219 | 203 | 271 | 259 | 203 | 251 | 214 |
| % of population | 100.0% | 20.0% | 0.9% | 1.3% | 1.0% | 0.9% | 1.5% | 0.9% | 0.8% | 1.1% | 1.1% | 0.8% | 1.0% | 0.9% |
| Mean Electricity (kWh) | 3,903 | 2,788 | 4,619 | 3,333 | 3,353 | 2,983 | 2,743 | 2,984 | 2,964 | 3,852 | 3,035 | 2,835 | 3,067 | 2,970 |
| Mean Gas (kWh) | 16,817 | 12,211 | 23,124 | 17,794 | 17,175 | 16,330 | 16,390 | 15,150 | 14,601 | 19,984 | 17,286 | 15,960 | 14,291 | 13,958 |
| Mean Combined (kWh) | 18,222 | 12,482 | 27,743 | 21,127 | 20,527 | 19,313 | 19,133 | 18,134 | 17,565 | 23,836 | 20,320 | 18,795 | 17,357 | 16,928 |
| Rurality | Urban | Urban | Urban/ fringe | Urban | Urban | Urban | Urban | Urban | Urban | Urban/ fringe | Urban | Urban | Urban | Urban |
| Central heating | Gas | Gas | Gas | Gas | Gas | Gas | Gas | Gas | Gas | Gas | Gas | Gas | Gas | Gas |
| Built form | Semi | Flat / terrace | Detached | Semi | Detached / semi | Semi | Semi | Semi | Semi | Detached | Semi | Semi | Terrace | Terrace |
| Number of rooms (mean) | 6 | 5 | 8 | 5 | 7 | 6 | 5 | 5 | 6 | 8 | 5 | 6 | 5 | 5 |
| Tenure | Mortgage | SOC rented | Owned outright | Owned outright | Owned outright | Owned outright | Owned outright | Owned outright | SOC rented | Owned outright | Owned outright | Owned outright | OO/ mortgage | SOC rented |
| Employment status | Full time | Retired / NW | Mix | Retired | Retired | Retired | Retired | Retired | Retired / working | Retired | Retired | Retired | Not working | Not working |
| Age of HRP (mean) | 52 | 59 | 61 | 64 | 69 | 68 | 67 | 62 | 53 | 65 | 75 | 75 | 51 | 49 |
| No. of adults (mean) | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. of children (mean) | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Occupant over 70 | No | No | No | No | Yes | Yes | Yes | No | No | 50/50 | Yes | Yes | No | No |
| Claiming benefits | No | Yes | No | No | No | No | No | No | Yes | 26.5% | 37.0% | 37.4% | 25.8% | 85.8% |

SOC = social rented; PRS = private rented; NW = not working (under minimum state retirement age, but not registered unemployed)

Annex 4 Expenditure and ‘low income’ households

This report has applied an income-based approach in exploring the energy consumption patterns of poor households in Great Britain. Ranking households by their expenditure rather than income offers an alternative approach to distributional analysis.

Research by the Office for National Statistics has explored this concept, particularly in the context of the effect of taxes. Its analysis of the distribution of household disposable income and total household expenditure suggest some key socio-demographic differences in the two approaches. For example, single parents, couples with children and those in full-time education appeared more equally spread in expenditure distribution compared to income distribution, where they appear more concentrated in the bottom quintile¹⁶.

‘Equivalised expenditure’ is a concept also applied by HMT and HMRC in its budgetary analysis, as it offers the opportunity to explore poverty from a different perspective. This stems from recognition that a number of households in the bottom income quintile may actually be either: asset rich with large savings; in full time education with external financial support; or temporarily out of work. Comparing income levels with (equivalised) expenditure can help to isolate these cases and thus ensure attention is focused more closely on the lowest income households.

Consistent with the approach of ONS, HMT and HMRC, the analysis below uses total household expenditure recorded in the EFS. Both total expenditure and household disposable income are equivalised using the OECD-modified scale¹⁷.

Total household expenditure

The mean annual total household expenditure, based on the EFS GB dataset, is approximately £23,000. This compares to an average annual household disposable income of just over £26,750. Equivalised values are lower at £14,000 and £16,500 respectively (Annex Table 11).

Annex Table 11. Summary statistics: household income and expenditure (based on EFS GB dataset)

| | Mean | Median |
|---|---------|---------|
| Annual gross income | £33,004 | £25,768 |
| Annual equivalised gross income [OECD] | £20,306 | £16,168 |
| Annual disposable income | £26,765 | £21,817 |
| Annual equivalised disposable income [OECD] | £16,525 | £13,759 |
| Total annual expenditure | £23,354 | £19,296 |
| Total annual equivalised expenditure [OECD] | £14,415 | £12,133 |

¹⁶ ONS, 2010. *An expenditure-based analysis of the redistribution of household income*. Economic and Labour Market Review, vol 4 (3), March 2010. www.statistics.gov.uk/elmr/03_10/downloads/ELMR_Mar10_Carrera.pdf

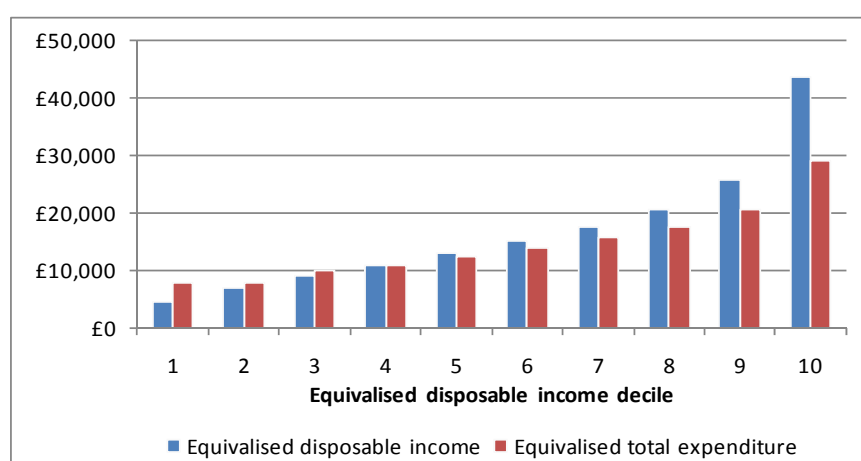
¹⁷ Equivalisation is a means of adjusting income according to household composition. The income equivalence scale can also be applied to household expenditure. For more information, see: www.statistics.gov.uk/elmr/01_10/downloads/ELMR_Jan10_Grace.pdf

Annex Table 12. Average annual household expenditure by decile

| Decile | Total annual expenditure | | Total annual equivalised expenditure | |
|--------|--------------------------|---------|--------------------------------------|---------|
| | Mean | Median | Mean | Median |
| 1 | £4,295 | £4,463 | £3,671 | £3,859 |
| 2 | £7,826 | £7,863 | £6,049 | £6,056 |
| 3 | £10,981 | £10,987 | £7,883 | £7,904 |
| 4 | £14,233 | £14,234 | £9,550 | £9,547 |
| 5 | £17,585 | £17,581 | £11,261 | £11,253 |
| 6 | £21,136 | £21,142 | £13,081 | £13,064 |
| 7 | £25,258 | £25,223 | £15,215 | £15,197 |
| 8 | £30,423 | £30,272 | £17,994 | £17,943 |
| 9 | £38,242 | £37,975 | £22,268 | £22,082 |
| 10 | £63,559 | £55,468 | £37,170 | £32,307 |

The highest expenditure decile has a mean annual equivalised expenditure some eight to ten times greater than that of the lowest expenditure group (Annex Table 12). However, the average expenditure by (equivalised) income decile group shows a flatter distribution (Annex Figure 5): whilst on average income more than doubles from the lowest income decile to decile 4, expenditure increases by a factor of less than 1.5 over the same income decile groups, which alludes to the presence of high expenditure households within the lowest income deciles.

Annex Table 13 and Figure 6 provide further evidence of this: whilst nearly 60% of those in the lowest income quintile, are in the lowest expenditure group, there are some 600 thousand 'low income' households that have high annual expenditure¹⁸. These households have an average annual expenditure over three times their income (Annex Table 14), suggesting their low income status maybe temporary; they may have external financial support (e.g. from family or credit); or they may be asset rich. It is these households that may be misrepresented as 'poor' by income-based definitions (though their ability to sustain this 'excess' expenditure is not examined).

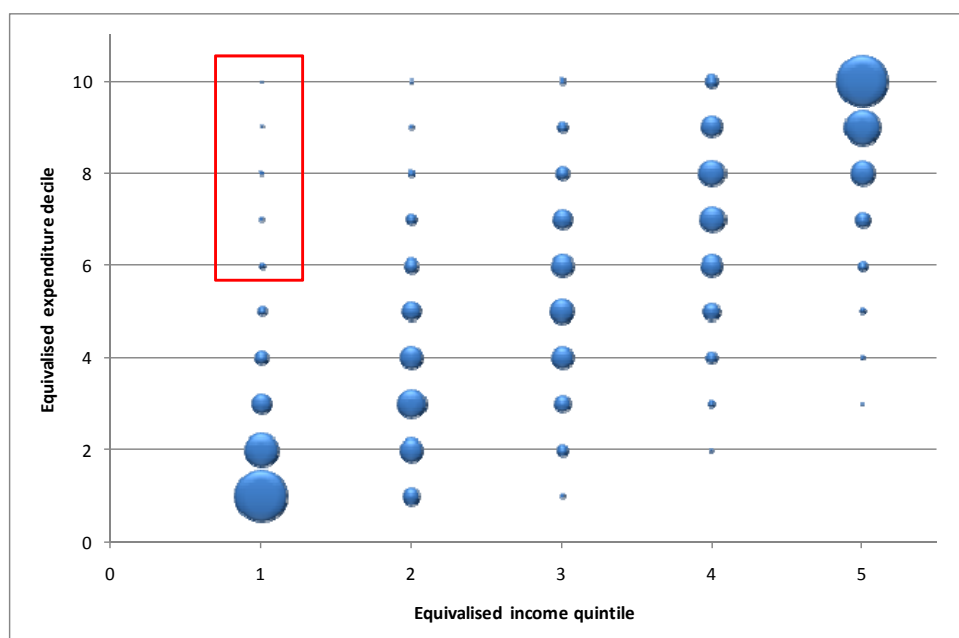
Annex Figure 5. Mean annual equivalised household expenditure and disposable income, by income decile

¹⁸ Where 'low income' includes households in equivalised income quintile 1 and 'high expenditure' is those in equivalised expenditure decile 6 and above.

Annex Table 13. Proportion of households in income poverty and the lowest equivalised income quintile by expenditure group.

| Equivalised expenditure quintile | HH in income poverty | Income quintile 1 (equivalised) |
|----------------------------------|----------------------|---------------------------------|
| 1 | 51% | 58% |
| 2 | 25% | 23% |
| 3 | 12% | 10% |
| 4 | 7% | 5% |
| 5 | 4% | 3% |
| <i>Total N (000s)</i> | 6,734 | 4,841 |

Annex Figure 6. Distribution of households by (equivalised) income and expenditure quintile (width of bubbles represents (weighted) number of households)



Annex Table 14. Low income high expenditure households

| | | HHs in income quintile 1 & expenditure decile > 5 | Remaining population |
|---|--------|---|----------------------|
| Annual disposable income | Mean | £7,790 | £27,261 |
| | Median | £7,282 | £22,411 |
| Total annual expenditure | Mean | £28,314 | £23,224 |
| | Median | £23,887 | £19,135 |
| Annual equivalised disposable income | Mean | £5,090 | £16,824 |
| | Median | £5,746 | £14,026 |
| Equivalised total expenditure | Mean | £18,912 | £14,297 |
| | Median | £16,044 | £11,910 |

Energy consumption of low income high total expenditure households

Further analysis of the 'low income, high expenditure' households in the EFS dataset suggests that the energy consumption of these households is very similar to the average for the dataset as a whole (Annex Table 15), and the households are mainly:

- gas centrally heated, urban and fringe properties (a mix of houses and flats) with 4-6 rooms;
- private sector, with 20% being privately rented (double the average);
- high proportion is self-employed (18%, compared to an overall average of 8%);
- high proportion are 'unoccupied' (under retirement age but not working, 33% compared to 12% overall average);
- a greater number of single adults, with slightly higher proportions of 16-24 and 55-64, fewer over 65.

Annex Table 15. Energy consumption of low income high expenditure households (figures in brackets show the averages for the whole dataset)

| Annual kWh | Mean | Median |
|---------------------------------|--------------------|--------------------|
| Electricity | 4,042 (3,903) | 3,408 (3,426) |
| Gas (supplied HHs only) | 16,843 (16,817) | 15,125 (15,375) |
| Elec. & gas combined | 18,017 (18,222) | 16,533 (16,886) |

Further analysis could be undertaken on the low income subset with these high expenditure households excluded. In particular, we could examine the number of retired households categorised as low income high energy expenditure in the CHAID analysis that actually have high overall expenditure. For example, nodes 5 and 19 in section 3.1 may contain a number of households with high expenditure.