Abstract This paper maps the percentage of household expenditure devoted to energy by UK households over the past 25 years. Mapping household energy expenditure shares over the long-run provides a solid evidence base for discussing the distributional aspects of the UK’s retail energy market. By looking over the long-run recent high expenditure shares are placed in context with low energy expenditure shares in the late 1990s and early 2000s appearing more exceptional. The large variations in energy expenditure shares across households, and through time, highlight the varying political saliency of energy and the dramatically more pressing budget choices facing low income households after energy price rises. While increased affordability pressures over the past 10 years support the political expediency of recent commitments to re-regulate energy prices, it is striking that many affordability support policies were first introduced when energy was at its most affordable. Casual empiricism suggests government ideology and the election cycle may be as important as energy expenditure shares in determining affordability support policies.

1. Introduction

Distributional issues are currently to the fore in the UK retail energy market as the traditionally pro-market Conservative party has included a price cap designed to limit price variations between ‘active’ and ‘inactive’ consumers as part of its 2017 election manifesto. This paper provides the most extensive exploration yet of energy expenditure shares (ENEXShr) across different UK households. The analysis corrects for a serious measurement issue regarding pre-payment meter (PPM) energy expenditures (ENEX) and goes beyond existing work to look at ENEX and ENEXShr distributions by a wider range of household characteristics. Time series of official Fuel Poverty (FP) metrics are replicated using actual rather than required ENEX producing evidence that challenges the FP literature’s general assumption that actual ENEX will under-estimate FP. The picture of energy affordability pressures obtained provides evidence to answer distributional questions regarding the UK’s energy market. The second half of the paper maps affordability support policies alongside ENEXShr. Against expectations, many support policies were introduced when ENEXShr was low rather than high. Casual empiricism suggests government ideology and electoral cycles may be as important as affordability pressures in the timing of support policies.

In one sense the attention given to equity and distributional concerns in the UK is surprising since average ENEXShr in the UK are not exceptional, being noticeably lower than in the EU’s New Member States. Yet, since the 1990s, there has been a growing literature and policy action on ‘Fuel Poverty’ (FP) or the ‘unaffordability’ of energy for certain groups. The current paper shows that whether...
current ENEX appears exceptionally high depends on the period studied and whether ENEX are in real or nominal terms. While compared to the early 2000s ENEX and ENEX$_{Shr}$ currently appear very high, their values are in line with those in the late 1980s and early 1990s. In the longer run the low ENEX$_{Shr}$ of the early 2000s appear more exceptional. Consumers’ concerns regarding ‘energy prices always going up’ are better understood by looking at nominal ENEX. Nominal ENEX shows remarkable stability between 1992 and 2003–04, before doubling over the following decade. These results are reported in Section 4 after a discussion of existing literature in Section 2 and the study’s data and methodology is discussed in Section 3.

The reported ENEX$_{Shr}$ and ENEX patterns, and the energy market’s political risk, are unsurprising given the price and income inelastic nature of residential energy demand which reflects energy’s status as a necessity. Inelastic demand explains why: (a) lower income groups have higher ENEX$_{Shr}$, and (b) ENEX$_{Shr}$ is positively correlated with energy prices through time. The median equivalised after housing costs household ENEX$_{Shr}$ in 2014 was 17.3% for those in the bottom income decile compared to 6.6% for the top income decile. Similarly, while between 2003–04 and 2014 the median ENEX$_{Shr}$ of households in the bottom income decile increased by 7.3 percentage points the top income decile’s median ENEX$_{Shr}$ rose by only 2.6 percentage points. These figures show the proportionate welfare impact of rising energy prices varies significantly by income level: while for those at the top of the income distribution the rise in ENEX may be inconvenient, for those at the bottom it resulted in serious budget choices. The converse of this statement is that declining ENEX$_{Shr}$ during the 1990s provided greater proportionate welfare gains to those at the bottom of the income distribution. In an age of increasing distributional concerns it is therefore unsurprising that energy has become a lightning rod for political and media comment.

Beyond analysing ENEX$_{Shr}$ by income decile, in Section 5 the ENEX$_{Shr}$ time series is analysed by factors including: age of household head, household composition, tenure and devolved administration. ENEX$_{Shr}$ are consistently elevated for households headed by someone over the age of 70, those living in social housing and those paying by PPM. The message from this analysis is that heightened ENEX$_{Shr}$ appear to result from total expenditure (income), rather than ENEX, differences. The only convergence, for single parent households and Northern Ireland, appears to result from total expenditure increases. This argues against treating FP as a problem separate from general poverty.

These results are obtained after applying a significant correction related to PPM users’ energy expenditures. By the early 2000s around 50% of PPM users were reporting zero expenditure on their PPM, but reports of zero expenditures all but disappeared following a survey question change in 2013. Utilising data from a range of sources we argue that these ‘excessive zeros’ are best treated as missing data. This is significant since it implies that without an appropriate correction average PPM energy expenditures produced from Living Costs and Food Survey (LCF) data (and its precursors) systematically under-estimate true PPM expenditures by a large margin. This is important for any distributional analysis related to energy since PPMs are highly concentrated in low income and single parent households and in social housing. Section 2 highlights existing work which may be affected by this issue.

---

5 For example, Dimitropoulos et al (2005) estimate the long-run price elasticity of residential energy in the UK to be -0.23 and the long-run income elasticity to be 0.34.

6 All references to ENEX$_{Shr}$ use this definition unless stated otherwise.

7 Based on equivalised after housing costs income.

8 By devolved administration we mean each of the constituent elements of the UK: England, Scotland, Wales and Northern Ireland.
The apparent importance of total expenditure in determining ENEXShr suggests a limited impact, up to now, for affordability support policies in delivering step-changes in energy affordability across household groups. In Section 6 the timing of support policies is mapped against ENEXShr with a focus on transfer payments and FP Strategy (FPS). It is striking that the most costly payment, Winter Fuel Payments (WFP), was introduced in 1997 by the incoming Labour (left of centre) government and was significantly increased during the early 2000s when ENEXShr was low. That WFP is targeted at pensioners (a group more likely to vote) rather than by income and that increases in the WFP’s value often occurred close to elections might invite cynicism regarding the policy’s motivations. The first FPS in 2001 also occurred when affordability pressures were low, but was introduced as a result of actions by an opposition MP in parliament rather than by government. This might explain why an ambitious FP target was initially adopted and that as energy affordability pressures rose the government responded by downgrading its ambitions.

To assess energy affordability ENEXShr are used rather than energy prices as they also reflect: (a) households’ income, (b) energy efficiency, and (c) changes in the quantity of energy consumed. For example, the impact of rising energy prices on household welfare may be dampened by rising incomes or increased energy efficiency. Also, ENEXShr has been deliberately chosen over FP statistics. As Deller (2016) explains, the disadvantages of FP statistics are twofold: firstly, headline FP statistics are binary, so analysing the full ENEXShr distribution provides additional information; and, secondly, FP statistics have their own statistical properties which may affect intertemporal comparisons9. Nevertheless, in Section 7 the assembled expenditure data is used to construct estimates of FP rates. This enables a detailed comparison of FP rates for different household groups using actual ENEX rather than the required ENEX10 used in official FP statistics. A complex picture emerges regarding the relationship between FP rates using actual and required ENEX suggesting that the FP literature’s common assumption that actual ENEX underestimates FP11 is too simplistic. The failure to correct for the PPM ENEX measurement issue may have distorted previous FP results and conclusions.

2. Existing Literature

The current paper builds on the methodology and policy detail of Advani et al (2013). Compared to Advani et al (2013) the current paper differs in three respects. First, and most significantly, a different, and we believe more appropriate, correction for the presence of a high number of ‘zero expenditures’ among PPM households is applied. Second, whereas Advani et al focus on producing a detailed distributional analysis of energy policy in 2009-10, the current paper maps ENEXShr by a range of household characteristics over the long-run. Third, the current paper calculates FP statistics for England and compares these to official FP statistics.

The present analysis also follows on from the work of Waddams and Deller (2015) and Deller (2016). Again the current paper departs from this earlier work by applying a more sophisticated methodology to calculate ENEXShr. The earlier papers also differ in emphasis by comparing affordability across multiple EU states and comparing the behaviour of alternative FP statistics. Detailed comparisons between actual and required ENEX have been made by Hirsch et al (2011) and BRE (2013). The current paper complements these earlier works by comparing FP rates broken down by a range of household characteristics in multiple years. The present work highlights that the relationship between actual and

10. Required ENEX refers to the expenditure required for a household to heat their home to a specified temperature (and achieve a specified level of lighting and cooking) according to a model incorporating a dwelling’s physical characteristics. A detailed explanation of the model is provided in DECC/BRE (2016).
required ENEX can change through time. Also, compared to Hirsch et al (2011), the PPM correction is applied.

In addition to Advani et al, Levell and Oldfield (2011) investigate low income households’ spending patterns with particular reference to domestic fuels. Levell and Oldfield reinforce this paper’s message that the impact of energy price fluctuations varies substantially by income. Levell and Oldfield find that in 2006 fuel price inflation increased the inflation rate of the lowest income quintile by 1.8 percentage points, but added only 0.8 percentage points to the top income quintile’s inflation rate.\footnote{Inflation rates differ due to products having different weights in the overall expenditure of different income deciles.} The far greater proportion of PPM users among lower income households\footnote{Averaging our sample data between 1992 and 2014, 20% of households in the bottom income decile have a PPM for at least one fuel compared to 10.5% in the fifth income decile and 1.6% in the top income decile. One reason for lower income being associated with greater PPM use is the installation of PPMs by energy firms to manage debt. Ofgem (2016) provides a discussion of this issue.} implies that, if the current PPM correction was applied, the contribution of fuel price inflation to the inflation rate of the bottom income quintile probably would be higher.

The apparent under-reporting of PPM users’ ENEX not only affects analysis of the distribution of ENEX, it also potentially affects the analysis of carbon emissions across UK households. A mini-literature exists which has used modelling to take ENEX from the LCF and convert it into energy consumption and carbon emissions. Studies utilising this methodology include: Dresner and Ekins (2006), Druckman and Jackson (2008), Thumim and White (2008), Fahmy et al (2011), Gough (2011), Buchs and Schnepf (2013a), Buchs and Schnepf (2013b) and Hargreaves et al (2013). These studies include analysis of carbon emissions by income level and find a positive relationship between income and carbon emissions. While not evaluating these studies in detail, if PPM users’ true ENEX is significantly above that in the raw LCF data one would hypothesise that the positive relationship between income and carbon emissions would be somewhat softened. The extent of this softening and whether it is of material importance (one suspects it might only change quantitative rather than qualitative results) is beyond this paper’s scope. Nevertheless, the current study emphasises the advantage of using actual energy consumption for distributional analysis, as is performed by Chatterton et al (2016).

A range of papers investigate determinates of UK households’ ENEX. An early example is Baker et al (1989) who utilise a two-stage budgeting framework, while Baker and Blundell (1991) estimate price and income elasticities for gas and electricity by season, central heating fuel and tenure. Crawford et al (1993) explicitly look at the distribution of ENEXShr by income as part of work to simulate the distributional impacts of imposing VAT on energy. The age of these papers mean the Family Expenditure Survey data they use is much less affected by the PPM data issue.\footnote{Figure A3 of Advani et al (2013) shows less than 10% of PPM users reported zero expenditure throughout the 1980s.} Other papers looking at UK ENEX are unaffected by the PPM data issue as they utilise the British Household Panel Study (BHPS).\footnote{Although, Pudney (2008) highlights other issues with BHPS ENEX data.} For example, Meier and Rehdanz (2010) consider determinants of ENEX split between renters and home owners, while Meier et al (2013) further investigate the relationship between income and ENEX.

3. Data and Methodology

Data comes from the LCF and its precursor surveys, the Expenditure and Food Survey and the Family Expenditure Survey. These are annual cross-sectional surveys that are designed to be nationally
representative with each sampled household having their data collected once. The data is used to form an annual time series from 1992 to 2014, with further context provided by observations in 1977, 1982 and 1987. The surveys’ total sample sizes vary between 4,900 and 7,500 households. To deal with sampling issues weights are applied.¹⁶

ENEX figures are annualised¹⁷ and defined as all those incurred by adult household members on all fuels¹⁸ to provide fuel, light and power to their home (transport expenditures are excluded). All ENEX figures are converted to 2014 prices using the Retail Price Index (RPI)¹⁹. ENEXShr is calculated as a proportion of total household expenditure. Total expenditure is used rather than income due to the former displaying less volatility and probably providing a better indication of living standards.²⁰ As the paper aims to identify energy affordability pressures, total expenditure is calculated after housing costs have been deducted and is equivalent using the modified OECD scale²¹. These procedures are performed as housing costs reflect long-term decisions and offer limited flexibility for adjustment, while equivalisation recognises that households with more members place greater demands on a given quantity of resources. If housing costs were not deducted, the total expenditure of those paying rent would be inflated relative to those owning their homes outright.²²

Before analysing ENEXShr two more complex corrections are applied. First, as understanding the full distribution of ENEX/ENEXShr and calculating FP statistics is an explicit aim of the research, ENEX has been de-seasonalised. The precise form of seasonality varies by payment method (Direct Debit, Arrears, PPM)²³, but the intuition for a seasonality correction is clear: seasonal temperatures mean heating expenditures are systematically higher in winter. If a seasonality correction was not applied, whether a household was in the upper or lower tail of the ENEX/ENEXShr distribution would be linked to the month when they were interviewed.

The seasonality corrections for Arrears and Direct Debit follow Advani et al (2013). Separate OLS regressions for Direct Debit and Arrears for each fuel (electricity and gas)²⁴ are run in each year. The dependent variable in these regressions is log ENEX and the explanatory variables include interview

---

¹⁶ Official survey weights are used when available. Prior to 2001-02 weights have been calculated using a simplified version of the official methodology comparing the survey sample with census data. The simplified weights are based on the following characteristics: gender of the household head, age group of the household head and region/devolved administration. The weights between 1992 and 2000-01 utilise the 1991 census, while the weights for earlier years utilise the 1981 census.

¹⁷ The raw data is reported as weekly equivalents.

¹⁸ The survey records gas, electricity, oil, bottled gas, coal/coke, paraffin, wood/peat and heat/steam expenditures separately. ENEX related to second homes is included.

¹⁹ ENEXShr, as a fraction, is independent of inflation measure choices. However, the choice of CPI or RPI will affect the variations through time of real ENEX. Since CPI is generally lower than RPI, using CPI will make ENEX in earlier years fall relative to the data reported in this paper.

²⁰ For example, see Brewer and O’Dea (2012).

²¹ This is described in ‘What are equivalence scales?’, available at: http://www.oecd.org/eco/growth/OECDNote-EquivalenceScales.pdf

²² Equivalisation and the deduction of housing costs mean the reported ENEXShr are mechanically larger than the actual proportion of expenditure devoted to energy. Equivalisation and deducting housing costs increases the median ENEXShr in 2014 from 5.2% to 10.4%. Non-equivalised ENEXShr before the deduction of housing costs is reported in Figure A3.1. The data behind Figure A3.1 still has seasonality and PPM corrections applied.

²³ Direct Debit is where money is automatically taken from a customers’ bank to pay a bill every month or quarter; Arrears is where a customer is sent a bill, usually once a quarter, asking for payment covering the previous quarter’s consumption; and, lastly, PPM requires consumers to pay for energy before use, with this generally involving topping up an electronic card at a local shop.

²⁴ Due to the small number of observations involved no corrections are applied to ENEX involving other fuels or other payment methods.
month dummies and a comprehensive range of household characteristics. Utilising the month dummies’ co-efficients notionl ENEX as if a household had been interviewed in different months can be estimated. To produce a de-seasonalised estimate of a household’s annual ENEX a simple average is taken of the twelve ENEX estimates corresponding to the different possible interview months. Total ENEX for each household is produced by summing the estimates/observations for individual fuels.

The PPM Correction

Correcting PPM expenditures is more involved and departs from the methodology of Advani et al (2013). To understand the issue of PPM expenditure data containing ‘excessive zeros’ the collection process for ENEX data prior to 2013 needs to be understood. If a consumer paid by Arrears or Direct Debit, they stated the amount of their last energy bill and the period which it covered. As PPMs allow frequent top-ups at irregular intervals, PPM ENEX was collected in a two week ‘expenditure diary’, the same approach as for food. This expenditure diary approach meant that if a PPM user did not top-up within the specified two week window their PPM ENEX for the two week period would be recorded as zero leading to their annual PPM ENEX also being zero.

Figure 1 shows the percentage of zero observations steadily increased during the 1990s until around 50% of gas PPM consumers were reporting zero gas expenditure in the first decade of the 21st century. This increase roughly correlates with a steady decline in the median ENEX recorded by PPM consumers. Figure 1 also shows an abrupt change in the percentage of zeros and median ENEX between 2012 and 2013. PPM consumers no longer reporting zero gas/electricity expenditures in 2013 and 2014 corresponds to a fundamental data collection change. From 2013 PPM consumers were asked a two-part question similar to that for other payment methods: the first question asked “How much did you last put on your key/meter?”, while the second question asked “How long would this amount normally last as this time of year?” This change is associated with the median total ENEX of electricity PPM users more than doubling from £588 to £1334.

Figure 1 suggests that: (a) PPM ENEX prior to 2013 was subject to a serious measurement issue, and (b) this measurement issue is linked to the expenditure diary methodology. We argue that zero ENEX for PPM users is most appropriately treated as missing data. Treating the zeros as missing observations we run OLS regressions to impute values for PPM expenditures recorded as zero in the raw dataset prior to 2013. Separate OLS regressions are run for gas and electricity in each year. The dependent variable is expenditure on the relevant fuel while the explanatory variables are the same as those in the seasonality regressions. The regressions are estimated using data from PPM users recording positive expenditure in the relevant year. The coefficients from these estimations are combined with the values of the explanatory variables for those PPM users reporting zero PPM expenditure to create

25 The household characteristics are: region/devolved administration, household composition, gender of household head, equivalised after housing costs income decile, age of household head, employment status of household head, number of cars owned, type of dwelling, tenure type, number of rooms in the dwelling, central heating fuel, whether there is an internet connection and whether household appliances are owned (tumble dryer, microwave, dishwasher, TV).

26 We do not have an explanation for why the percentage of zeros increased so dramatically. However, during the 1990s, the percentage of households with PPMs increased, PPMs were increasingly used for debt management and PPM technology switched from inserting tokens/coins into a PPM to electronic top ups.

27 The ENEX in Figure 1 is ‘raw’ i.e. it is unweighted and has neither the correction for seasonality or excessive zeros applied.

estimates of their PPM expenditure if it had been recorded. For households with positive PPM expenditure in the raw data their actual expenditure values are used. Both the imputed and unimputed PPM expenditures are then deseasonalised.

Our decision to follow a different correction method to Advani et al (2013) takes advantage of the additional data available after 2010, in the data available to Advani et al which ended in 2010 there was no change in question format to observe. Given the jump in median ENEX between 2012 and 2013 our correction explicitly aims to increase average PPM ENEX. Advani et al applied a correction assuming average PPM expenditure in the raw data was correct and the excessive zeros simply increased the dispersion of ENEX. The key assumption of Advani et al’ s correction is that the majority of PPM consumers top-up less frequently than once every two weeks. If households topped up in this way it would imply: (a) the zeros are true observations for the two week window but are not representative of annual expenditure, and (b) positive expenditures recorded in the two week window are ‘too high’, i.e. they cover a period longer than two weeks.

To correct for the PPM data issue as they see it, Advani et al apply a two-step Tobit/Heckman selection model. The central contrast between our correction and Advani et al’s is that we treat positive PPM expenditures in the raw dataset as correct values, whereas Advani et al produce estimates for all PPM users. Advani et al’s estimation methodology means previously zero expenditures are replaced with positive expenditures and previously positive expenditures are replaced with smaller positive expenditures.

Figure 1 – Percentage of PPM Customers with Zero Expenditure plotted against Median ENEX for Electricity PPM Customers

29 This method assumes any differences in ‘true’ PPM ENEX between those recording zero PPM expenditure and those recording positive PPM expenditure is accounted for solely by households’ observable characteristics.
The detail of why PPM zero expenditures are most appropriately treated as missing data is provided in Appendix 2. The argument is based on the combined weight of evidence which can be summarised as:

(i) Changing the data collection methodology removes the excessive zero issue;

(ii) The extreme increase in median ENEX for PPM users between 2012 and 2013 does not occur for Direct Debit or Arrears users;

(iii) Pricing data does not show a significant jump in PPM prices between 2012 and 2013;

(iv) Two surveys report that households topping up PPMs less frequently than once every two weeks is rare;

(v) Only a small proportion of zero expenditures might plausibly be due to an absence of gas expenditures on heating in summer months;

(vi) In expenditure surveys with thousands of expenditure items, expenditure on items is set to zero unless a respondent records positive expenditure i.e. zeros can plausibly mask missing data.

While treating PPM zeros as missing data appears most appropriate, we recognise that for a small proportion of summer gas PPM observations Advani et al’s methodology may be more appropriate and that for a very small number of households with a gas connection their true annual gas expenditure might be zero. For these reasons the ENEX and ENEXShr we report are upper bounds.

Statistical Testing

The volume of data mean statistical tests are restricted to key relationships. When looking at time trends, statistical tests of differences between years compare 1992, 2003-04 and 2014 for the overall median and for the income decile medians reported in Figure 5. For the breakdowns by household characteristics reported in Section 5, statistical tests of the differences between household groups have again been performed in 1992, 2003-04 and 2014. Further detail on the test results is reported alongside the relevant Figures. For each comparison three statistical tests have been performed: (i) a non-parametric equality of medians test, (ii) the Wilcoxon rank-sum test/Mann-Whitney two-sample statistic, and (iii) a quantile (median) regression with a single explanatory variable representing the difference being compared. Generally the three statistics report similar results. As the PPM imputation artificially restricts the sample variance compared to when no PPM measurement issue existed (the imputed PPM values exclude ‘randomness’). The validity of the statistical tests in years prior to 2013 may be affected. However the severity of this issue must be kept in context as in any given year no more than 10% of observations were imputed.

At present statistical tests have not been performed for the FP statistics. Statistical tests for the 10% metric will be performed in the near future. Statistical tests of the LIHC metric require further thought with a valid statistical test being complex. This is because (a) the LIHC FP statistic is based on the intersection of two distributions (ENEX and income), and (b) the ‘low income’ and ‘high (energy) cost’ thresholds are themselves estimated.

4. ENEXShr Through Time

The central finding, visible in all the data, is that whether ENEXShr after 2010 are seen as exceptionally high depends on the period considered. In a 10 year perspective, i.e. when compared to the early 2000s, ENEXShr after 2010 appear high, but in a 20 or 30 year perspective, ENEXShr after 2010 is
similar to that of the late 1980s and early 1990s. In this longer term view the low ENEXShr, and easy energy affordability, of the early 2000s appear the more exceptional.

In Figures 2 and 3 median ENEXShr are reported relative to 1992. Figure 2 shows between 1992 and 2002-03 median ENEXShr fell by 46%, but that by 2012 this fall had been reversed. Figure 3 provides further detail showing that most of the rebound in median ENEXShr occurred between 2004 and 2009, with median ENEXShr then hovering around its 1992 level.

Figure 2 – Index of Median Equivalised After Housing Costs ENEXShr, Selected Years

Median ENEXShr reached a low of 6.7% in 2002-03 and 2003-04 and stood at 10.4% in 2014 (compared to 10.6% in 1992). That Median ENEXShr in 1992 and 2014 are the same as in 2003-04 can be

---

30 Years labelled 1997-98 and 2002-03 refer to instances where the survey was performed according to the financial year (April to April) rather than the calendar year.
statistically rejected at the 1% level. Comparing median ENEXshr in 1992 and 2014 only the Wilcoxon ranksum test rejects the null hypothesis that median ENEXshr are the same (at the 5% level). Among the years analysed the highest median ENEXshr was 12.3% in 1982. Figures A3.2 and A3.3 report the full distribution of ENEXshr.

Looking at median ENEX the key contrast is between ENEX in real and nominal terms. Figure 4 reports indices of median ENEX relative to 1992; the full distribution of ENEX in 2014 prices is reported in Figures A3.4 and A3.5. Figure 4 shows that in real terms, median ENEX between 1998-99 and 2005-06 was roughly 20% below its 1992 level, while ENEX since 2009 has been around 10% above its 1992 level. That median ENEX in 2003-04 was the same as in 1992 and 2014 can be rejected at the 1% level. Similarly that median ENEX was the same in 1992 and 2014 can be rejected at the 1% level. The time trend of median ENEX is similar to median ENEXshr, although the lowest index values of median ENEXshr in Figure 3 are lower, probably reflecting income (total expenditure) growth.

**ENEX Movements in Nominal Terms**

In explaining the energy market’s political economy it is worth contrasting real and nominal ENEX. The striking feature of Figure 4 is the remarkable stability of nominal ENEX between 1992 and 2003-04 compared to the doubling of nominal ENEX between 2003-04 and 2014. If consumers focus on nominal, rather than real, ENEX, i.e. their perception of the energy market is based simply on their energy bill’s nominal value, that the past decade has involved considerable political debate around energy prices appears easy to understand. Nominal ENEX’s time path supports adages such as ‘energy bills only ever go up’, and also a potential divergence in view between the public and ‘experts’ who focus on real ENEX.

If the public focuses on nominal energy bills, as seems likely, the bill increases after 2003-04 probably seem more salient due to the earlier decade of nominal stability. That average energy consumption has steadily declined since 2004 (see Figure A3.6), is likely to have furthered consumers’ sense of aggrievement.

![Indices of Median Energy Expenditures in Nominal and Real Terms](image)

**Figure 4 – Indices of Median ENEX in Nominal and Real Terms, 1992-2014**
While this paper is agnostic about the explanation for the sustained increase in ENEX, it is clear that increasing fuel input prices, in particular the gas price, must be part of the story. BEIS (2017) reports that the gas price paid by major power producers in nominal terms almost quadrupled between 2002 and 2013, rising from 0.609p to 2.299p per kWh.31

5. Expenditure Shares by Household Characteristics

In this section contrasts are drawn between the ENEXShr of different household groups. Breakdowns are provided by income decile, age of household head, household composition, tenure and UK nation. That many differences between household groups remain stable through time suggests the importance of total expenditure (income) in determining ENEXShr differences. In all of these breakdowns the overall ENEXShr time trend remains present.

Income Decile

The clear pattern in Figure 5 is that lower income deciles generally have higher ENEXShr. The magnitude of differences in ENEXShr seems likely to create fundamental differences in the salience of ENEX across income deciles. The median ENEXShr of the bottom income decile in 2014 was 17.3%, 2.6 times the ENEXShr of the top income decile (6.6%). The uneven salience of ENEX seems important to understand the politics of the UK energy market and energy policy. The patterns of ENEXShr above, and in Figure 6, highlight that energy is a market likely to have particular salience for two groups which politicians frequently focus on due to their electoral importance32: older households and, more recently, households who are “just about managing”33.

31 See Table 3.2.1 ‘Average prices of fuels purchased by the major UK power producers’ of BEIS (2017).
32 See Goerres (2007) for a discussion of the consistently higher voting participation of older households across Europe.
33 See “Just about managing’ families to be £2,500 a year worse off by 2020 – study’, by Patrick Butler and Rajeev Syal, The Guardian, Monday 21 November 2016, available at:
Figure 5 shows that in the early 2000s, when average ENEXShr was low, there was compression in the range of median ENEXShr across income deciles. In 2003-04 the range in median ENEXShr across income deciles was 6.4 percentage points compared to 10.6 percentage points in 2014. If standard preferences are assumed, such that households prefer consumption of a mixture of goods, it is intuitive that the 7.3 percentage point increase in median ENEXShr between 2003-04 and 2014 for households in the bottom income decile would feel a far more acute welfare reduction than the 2.6 percentage point increase in median ENEXShr of the top income decile. In all income deciles that median ENEXShr was the same in 2003-04 and 2014 can be rejected at the 1% level.

The most interesting feature of Figure 5 is that between 1996-97 and 2007 the lowest income decile always has a central estimate of median ENEXShr below that of the second income decile. Only in 2013 and 2014 did the lowest income decile’s median ENEXShr lie above that of the second income decile and one could reject the null of the two income decile’s median ENEXShr being the same. In seven years the lowest income decile’s median ENEXShr lay below that of the second income decile and one could reject the null that medians for the two income deciles were the same. Before further investigation is completed the range of possible explanations for this observation include: (i) households in the first and second income deciles have different characteristics; (ii) households in the first income decile have such low incomes that they have to disproportionately restrict their energy consumption to afford more vital goods e.g. food; (iii) the PPM correction is only partially effective; and/or (iv) other data issues occur at very low income levels.

**Age of Household Head**

Figure 6 highlights that older households generally have higher ENEXShr than younger households, with this being particularly true of households headed by someone aged 70+. This pattern is expected as older households probably have a higher demand for heat and retired households tend to have lower incomes than those in work. The important policy message is that energy affordability pressures are uneven across households receiving pensions. This is significant since the UK’s most costly energy affordability policy, WFP, is available to most households where the primary earners are aged 63 or over. Figure 6 supports resources being targeted at the very old and WFP does involve higher payments to those aged 80 or over. However, Figure 6 also suggests that WFP to households in the 60-70 age group may not be justified by need. A null that the median ENEXShr of the 60-70 and 70-80 categories are the same can be rejected at the 1% level in 1992, 2003-04 and 2014. A null that median ENEXShr of the 70-80 and 80+ categories are the same can be rejected statistically in 2003-04 and 2014.

Median ENEXShr of households in the 60-70 category are broadly similar to those of the 30-40 category. In contrast, in 2014 the median ENEXShr of the 80+ category was 1.5 times that of the 30-40 category. Median ENEX in Figure A3.7 shows that the high ENEXShr of the 80+ category is mainly due to their low total expenditure (income), with median ENEX of the 80+ category consistently being among the lowest of all age groups. In 2014 households in the 80+ category had a median ENEX which

---


34 As WFP is a social benefit it is recorded as an increase in income rather than a reduction in ENEX. While WFP is equivalent to a large proportion of households’ median ENEX (see Section 6), its recording as income moderates its impact on Figure 6.

35 See https://www.gov.uk/winter-fuel-payment/what-youll-get for the current eligibility criteria and payment rates.
was very close to that of the 15-30 category and considerably below the ENEX of ‘middle aged’ households.

![Median Energy Expenditures Shares by Age of Household Head, 1992-2014](image)

**Figure 6 – Median ENEXShr by Age of Household Head, 1992-2014**

**Household Composition**

As expected as the number of household members increases median ENEXShr tends to increase.\(^{36}\) However, Figure 7 shows there are exceptions to this general trend. From a policy perspective the most interesting case of households with fewer members having higher ENEXShr is that of single parent households\(^ {37} \). Figure 7 shows that until the mid-2000s households containing one adult and one child had a median ENEXShr noticeably above that for households containing a man, woman and two children. That the median ENEXShr was the same for these two household compositions is rejected by some tests in 1992 and 2003-04, but by none in 2014. Similarly households containing one adult and at least two children had a median ENEXShr noticeably above that for households containing two adults and at least three children. That the median ENEXShr for this second pair of household compositions were the same is rejected at the 1% level in 1992 and 2003-04, but was not rejected in 2014. The insignificance of the statistical tests in 2014 supports the apparent convergence of single parents’ ENEXShr to that of other families through time shown in Figure 7.

The lower median ENEX for single parents reported in Figure A3.8 suggests lower total expenditure/income is a key factor in explaining the higher ENEXShr of single parent households until the mid-2000s. Statistical tests generally reject the equality of median ENEX for the pairs of household compositions discussed in the paragraph above.

---

\(^{36}\) This is likely to be heavily influenced by the equivalisation and deduction of housing costs from total expenditure.

\(^{37}\) This term is used to cover all households containing one adult and children.
Figure 7 – Median ENEXShr of Selected Household Compositions as a Multiple of a Single Male’s Median ENEXShr

Regarding the convergence of single parents’ ENEXShr to that of other household compositions, there is a possible structural break in the ratios of median ENEXShr for single parent households relative to the median ENEXShr of single male households between 1999-00 and 2000-01. Between 1999-00 and 2000-01 the median ENEXShr of households containing one adult and one child fell by 2.2 percentage points and the median ENEXShr of households containing one adult and at least two children fell by 3.4 percentage points, while the median ENEXShr of the other household compositions featured in Figures 7 and A3.8 remained broadly flat. Statistical tests reject the equality of median ENEXShr in 1999-00 and 2000-01 for both types of single parent households. The equality of median ENEXShr in 1999-00 and 2000-01 is not rejected for any other household compositions in Figure 7, suggesting a change specific to single parent households.

That statistical tests do not reject median ENEX for single parent households (see Figure A3.8) being the same in both 1999-00 and 2000-01 suggests that the movement in single parents’ ENEXShr between these years results from a disproportionate increase in their total expenditure/income compared to other households. A possible candidate for such an increase might be the introduction of the Working Families Tax Credit during 1999-2000.  

Tenure

Figure 8 shows that between 1992 and 2014 median ENEXShr of those in social housing was consistently elevated compared to other tenures. During the period median ENEXShr for social housing is between 3.6 and 6.2 percentage points above that for private renters. The equality of these tenures’ median ENEXShr is rejected at the 1% level in 1992, 2003-04 and 2014. The persistence of this gap is striking given the noticeable reduction in social housing over this period and the rapid rise

---

38 See pg 12 of Blundell and Hoynes (2001) for a discussion of this policy’s impact.
39 Social housing refers to both council housing and housing provided by housing associations.
of private rented accommodation post-2000.\textsuperscript{40} It is also notable given the considerable investment in upgrading the social housing stock under the Decent Homes Programme after 2001.\textsuperscript{41} That Figure A3.9 shows median ENEX for social housing was broadly comparable to that of private renters and below that of home owners, again emphasises the apparent dominance of total expenditure/income in driving ENEX\textit{Shr} variations across household groups. This is reinforced by the average energy efficiency rating of social housing being noticeably higher than for owner occupied and private rented accommodation in Figure A2.2.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{median_enex_shr_by_tenure_1992-2014.png}
\caption{Figure 8 – Median ENEX\textit{Shr} by Tenure, 1992-2014}
\end{figure}

\textbf{UK Nation}

Considering median ENEX\textit{Shr} by devolved administration, the main trend in Figure 9 is the convergence between Northern Ireland and the other UK nations between 1982 and 1997-98. This convergence is despite median ENEX remaining elevated in Northern Ireland, for example, in 2014 the median ENEX in Northern Ireland was £1598 compared to £1220 in Wales. While the equality of median ENEX in Wales and Northern Ireland was rejected at the 1\% level in 2014, equality of median ENEX\textit{Shr} was not rejected. It seems a large part of the convergence was due to increased total expenditure (income) in Northern Ireland, a trend probably linked to the peace process and the Southern Irish boom.

\begin{itemize}
\item \textsuperscript{40} DCLG (2015) reports that between 1991 and 2013-14 the percentage of households in social housing fell from 23\% to 17\%, while the percentage in private rented accommodation rose from around 10\% in the 1990s to 19\% by 2013-14.
\item \textsuperscript{41} NAO (2010) reports estimates that, as of November 2009, 1.4 million local authority homes had received improvements at a cost of £22bn.
\end{itemize}
Figure 9 – Median ENEXShr by UK Nation for Selected Years

High ENEX in Northern Ireland is linked to a large number of households relying on oil fired central heating. The Consumer Council (2012) reports that 68% of Northern Irish households used oil compared to 7% of households in Great Britain. Looking across the UK, Figure A3.10 shows that households relying on oil fired central heating consistently had higher median ENEX and the gap relative to those with gas or electric central heating has increased since the late 1990s.

6. ENEXShr and Policy Interventions

A key motivation for assembling the ENEXShr time series is its use as evidence to shed light on policy interventions related to energy affordability in England42. A reasonable starting hypothesis would be that as ENEXShr and energy affordability challenges increase pressure for affordability support policies will increase leading to increased policy activity. However, the first FPS and WFP were introduced when ENEXShr was low. Casual empiricism suggests that decisions to provide energy affordability support are potentially influenced as much by governments’ ideological positions and the electoral cycle as by ENEXShr.

While noting the possible ability of energy efficiency schemes to reduce energy consumption and improve energy affordability, energy efficiency schemes are excluded from the discussion due to: (i) their complexity43, (ii) uncertainty regarding the relative importance given to reducing energy bills vs carbon emissions44, and (iii) uncertainty in the timing of their implementation and their impact on energy bills. Similarly, we do not map climate change policies and renewable energy decisions onto ENEXShr.

VAT, Transfer Payments and Rebates

---

42 The focus on England results from FP policies being the responsibility of the devolved administrations and the Northern Ireland energy market continuing to have price regulation administered by the Utility Regulator Northern Ireland.

43 Including supplier obligations, Advani et al report 11 major energy efficiency schemes between 1994 and 2013 (see pages 38 to 41).

44 The challenges of using single policies to meet both objectives are reviewed in Rosenow et al (2013).
Figure 10 annotates an index of ENEXShr with key policies involving VAT and transfer payments. The detail on the timing and structure of energy transfer payments is taken from Advani et al (2013). Cold Weather Payments (CWP) and WFP are state benefits and, as noted in footnote 34, they are additions to households’ income rather than deductions from energy bills. This means their impact on ENEXShr is not straightforward.\textsuperscript{45} The discussion aims to identify possible impacts of energy affordability on policy rather than the impact of policy on households’ ENEXShr. All transfer payments are reported in nominal terms.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure10.png}
\caption{Major Affordability Support Policies Mapped Against Indices of ENEXShr\textsuperscript{46}}
\end{figure}

**Cold Weather Payments** An early policy supporting energy affordability were CWP introduced in 1986 at the rate of £5 per week. These payments are made to those on a range of means tested benefits and are designed to compensate for the additional burden of high ENEX during particularly cold weather. A payment is made only if the average daily temperature at a household’s location is below 0°C for seven consecutive days, hence, CWP expenditure and the number of recipients is weather dependent.

Figure 5 suggests on distributional grounds that additional support for unexpected heating bills for those on benefits, i.e. low incomes, is legitimate. It may also represent an optimal sharing of risk with the government having a far greater ability to handle financial shocks than individual low income households. While total expenditure on CWP is unpredictable the headline payment per week indicates the generosity of support. There were some initial increases in the early- to mid-1990s, which probably aimed to preserve the CWP’s value in real terms\textsuperscript{47}, before 13 years of nominal stability when the CWP’s value eroded in real terms. The willingness to allow CWP to erode in real terms was possibly feasible due to median ENEXShr declining until 2003-04. It is noticeable that the uplift in CWP to £25 in 2008-09 occurred after ENEXShr had increased for 5 years and median ENEXShr had returned roughly to its position in 1995-96.

\textsuperscript{45}However, if the same monetary amount was delivered as a reduction in energy bills, it would have a larger impact on ENEXShr. This statement holds even if total expenditure equals income; an addition to the denominator (total expenditure) has less impact on a fraction’s (ENEXShr) value than a deduction from the numerator (ENEX) when the denominator is considerably larger than the numerator.

\textsuperscript{46}‘10\textsuperscript{th} percentile’ and ‘90\textsuperscript{th} percentile’ refer to the value of ENEXShr at these points in the ENEXShr distribution.

\textsuperscript{47}Advani et al reports that CWP increased to £6 in 1991, £7 in 1994 and £8.50 in 1995-96.
**VAT** The next major intervention affecting retail energy bills was the introduction of VAT on energy in 1994 at the rate of 8%. While 8% is a reduced VAT rate, holding everything else constant, one might expect this to increase ENEXshr. However, Figure 7 shows that between 1993 and 1995-96 the median ENEXshr index fell from 96.7 to 92.8. Similarly, the nominal median ENEX index remained flat between 1993 and 1995-96. This potentially supports the idea that falling pre-tax energy prices eased the introduction of this tax, however, undermining this, Figure A3.6 shows that average energy consumption fell by 7.5% between 1993 and 1995. In other words, reduced energy consumption limited ENEXshr moves.

The reduction in VAT to 5% in 1997-98 appears linked to the political cycle with the incoming Labour government having pledged this reduction in its 1997 election manifesto. That median ENEXshr declined by 6.8% between 1994-95 and 1996-97 indicates that this policy was not justified by worsening energy affordability.

**Winter Fuel Payments** The other key policy introduced by the new Labour government was WFP which is a lump-sum payment made to households containing individuals above the female pension age. Unlike the CWP, WFP is independent of weather conditions. WFP’s value has varied considerably, growing from something very modest to a significant expenditure item for government. Again much of this increase occurred prior to the upturn in ENEXshr after 2003-04. When introduced in 1997-98 the basic rate of WFP was £20 with an increased rate of £50 for those receiving income support, but by 2003-04 the basic rate was £200 with a higher rate of £300 for those aged over 80. As a result total WFP expenditure increased from £0.2bn to £1.9bn between 1997-98 and 2003-04. The changing generosity of WFP is shown in Figure 11 where WFP values are reported as a proportion of median ENEX for relevant age groups.

![Winter Fuel Payment as a Percentage of Median Energy Expenditures](image)

Figure 11 – Headline WFP as Percentage of Median ENEX for Relevant Age Groups

---

48 “We will cut VAT on fuel to five per cent, the lowest level allowed.”, see: [http://www.politicsresources.net/area/uk/man/lab97.htm](http://www.politicsresources.net/area/uk/man/lab97.htm)

49 Detail on WFP’s value and eligibility criteria is taken from Table 5.2, Advani et al (2013).

50 Note that strictly speaking Figure 11 is only indicative since the Median Energy Expenditure is generated based on the age of the Household Head rather than all occupants as is used when assessing WFP eligibility.
Figure 11 shows the main jump in WFP’s generosity occurred between 1998-99 and 2000-01, with a second jump for those aged over 80 between 2002-03 and 2003-04. A smaller proportionate increase in generosity for all groups occurred between 2007 and 2008. The increase between 1998-99 and 2000-01 is striking; in 1998-99 WFP represented 3.7-4.9% of median ENEX but by 2000-01 it represented 34.6-42.1%. Figure 6 indicates that while additional affordability support for those aged 70+, and especially those aged 80+, is potentially justified, median ENEXShr for those aged 60-70 is broadly in line with younger age groups. That a general election occurred in 2001 and older individuals are associated with an increased likelihood of voting\textsuperscript{51}, might lead one to wonder whether WFP eligibility for those below the age of 70 was linked to political expediency. This possibility is reinforced by the far greater generosity of the age related WFP compared to the income related CWP.

Also, significant additional payments were channelled through the WFP mechanism in 2004-05 and 2005-06 that have not been included in Figure 11 (this is one reason why Figure 11 differs from Figure 5.2 in Advani et al). Advani et al describes how in 2004-05 an extra £100 was directed through WFP to those aged 70+ to ease council tax bills, while in 2005-06 this additional element was increased to £200 for all WFP recipients aged 65 or over who paid council tax. Again this generosity seems to correspond with a general election in May 2005. As these increases were temporary they ceased in 2006-07.

A WFP change that does appear linked to energy affordability is the introduction of an increased rate of £300 for those aged 80+ in 2003-04. While Figure 6 shows a persistently elevated median ENEXShr for this group, when first introduced the increased rate WFP represented 68.9% of median ENEX of households in the 80+ category. It is interesting that in 2003-04 resources were allocated to increasing WFP generosity for those aged 80+ rather than to widen WFP eligibility to younger low income households. In 2003-04 median ENEXShr for the 80+ category was 9.7% compared to 9.9% in the bottom income decile and 10.4% in the second income decile.

A second WFP change potentially linked to affordability was a £50 increase in the standard WFP rate and a £100 increase for those aged 80+ in 2008-09 after a period of increasing ENEXShr.

**Warm Home Discount (WHD)** The final transfer payment change is the reduction in WFP, but introduction of WHD following the election of a coalition government in 2010. In 2011-12 the 2008-09 increases in WFP were reversed. As ENEXShr remained elevated compared to the early 2000s, this change probably relates to the general effort to reduce welfare spending under the ‘Austerity’ agenda. The interest feature of this dual change is the reduction in government WFP spending appears to have been offset by WHD\textsuperscript{52}, a policy financed via energy bills rather than general taxation and administered by large energy companies rather than government. It appears that rather than just cutting energy related welfare spending, the government ‘privatised’ a small part of the welfare system so that energy related support for low income pensioners remained stable but government spending fell.

WHD is an explicitly redistributive instrument financed by a charge on the bills of non-eligible households. WHD involves two elements: that focused on a ‘core group’ of low income pensioners specified by government and a ‘broader group’ of low income/‘vulnerable’ households\textsuperscript{53} chosen by individual companies. The core group receive the rebate automatically while broader group members must apply for the rebate. This ‘privatisation’ of an affordability support mechanism is not only

\textsuperscript{51} For example, see Goerres (2007).

\textsuperscript{52} Advani et al (2013) quote the value of the WHD bill rebate as being £135 in 2013-14.

\textsuperscript{53} ‘Vulnerable’ in this context generally refers to households containing the disabled, older people or young children.
interesting from a philosophical/ideological perspective, it may also have a meaningful impact on live debates regarding competition in the retail energy market.

A central element of the Competition and Markets Authority (CMA)’s investigation into the energy market, and its justification for intervention, is the substantially higher prices ‘inactive’ consumers, who remain with the incumbent pay, relative to ‘active’ consumers, who shop around. Implicit in the CMA’s argument is a distributional concern that inactive consumers tend to have lower incomes and lower educational qualifications. While WHD may be intended as an affordability support mechanism, its structure means its effects may be similar to price discrimination by large energy firms. WHD may distort the market because only large companies, mostly incumbents, have to provide WHD. Since WHD may not be provided by smaller firms, it potentially represents an additional switching cost deterring switching by WHD recipients to smaller entrants. As noted by the energy firm SSE, and disputed by the CMA, WHD eligibility may explain why certain ‘vulnerable’ groups are less likely to switch. The discretionary nature of the ‘broader’ element of WHD potentially aids incumbents’ attempts to protect their stock of existing customers. First, firms have some flexibility in selecting who receives the rebate. Second, that recipients must apply for the rebate means only relatively ‘active’ consumers will receive the bill reduction, precisely the consumers who, in the absence of the rebate, would have a greater switching propensity.

**Price Caps**

Recent proposals to re-introduce price regulation, via price caps, make it sensible to consider their relationship to affordability concerns. The intention is not to comment on price caps’ potential impact on competition, but whether affordability pressures may have encouraged re-regulation.

A difficult fact for those defending a liberalised energy market in political discourse is that relatively soon after the final removal of price controls a substantial increase in ENEX occurred. Given the level of ENEXShr after 2009, the party’s willingness to support energy affordability when in government and the media focus on energy prices it is unsurprising that Labour’s 2015 election campaign included a promise to freeze energy prices until the energy market could be “reset”. Predictably this led to the Labour leader being labelled ‘Red Ed’, while less predictably it has been followed by the CMA (2016) recommending a temporary price cap for PPM tariffs and the traditionally pro-market Conservative party entering the 2017 election promising to cap default tariff prices.

While the CMA (2016) argues for PPM tariffs on the grounds that structural impediments limit PPM competition, Figure 12 shows that PPM consumers’ median ENEXShr is consistently above that of other payment methods. The equivalence of median ENEXShr for Arrears and PPM users is rejected at the 1% level in 1992, 2003-04 and 2014. While a PPM price cap might reduce PPM ENEX, it is important to realise that the gap in ENEXShr appears to be mostly due to lower total expenditure by PPM users. Median ENEX for PPM users was around £48 higher than for Direct Debit customers in 2013 and only

---

54 For a discussion of the links between regulation, redistribution and social welfare see Levi-Faur (2014).
55 See CMA (2016a)
56 See Figure 2, page A9.1-24, CMA (2016b)
57 “Large” is those with more than 250,000 household customers.
58 See SSE (2015)
59 See CMA (2016c)
60 By ‘active’ consumers we mean consumers who have underlying characteristics meaning they are more likely to engage with ‘calls to action’ by energy suppliers.
around £5 higher in 2014.\textsuperscript{62} Nevertheless, as PPM users’ ENEXShr are high and PPMs are disproportionately located in low income households, ensuring that PPM prices are not excessively out of line from other payment methods is likely to attract political support.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure12.png}
\caption{Median ENEXShr by Electricity Payment Method, 1992-2014}
\end{figure}

It is more challenging to directly link the Conservative’s wider price cap proposals to explicit elements of our analysis, beyond the fact that ENEXShr is noticeably higher than in the early-2000s for those lower down the income distribution. Taking the price differential between default and fixed-term tariffs as a fact, perhaps the most important question is whether it is politically tenable for those on lower incomes/the vulnerable to be charged higher prices? While the CMA presents evidence suggesting lower activity leads to these groups being charged higher prices the picture is complicated by WHD. Although our analysis shows that in real terms ENEXShr post-2010 is similar to that in the early 1990s, it is unclear how salient this is compared to voters’ experiences over the past decade when ENEX have risen despite average energy consumption falling. However, it is possible that current political demands for action on energy prices has been intensified by government interventions in the early 2000s creating an expectation that government has a direct role in alleviating energy affordability concerns. Yet this raises further questions: to what extent were affordability support policies needed to make a fully liberalised energy market acceptable to a significant section of the population? Since the salience of energy varies across household categories (as judged by ENEXShr), is a fully deregulated energy market without affordability support policies or price caps a stable institutional structure?

While the public may demand specific energy affordability policies from their political leaders, a consistent message from Section 5 is that ENEXShr variations across households appear to be strongly linked to income variations across these groups. This is significant since UK debates on energy affordability have frequently been seen through the narrower lense of FP, where the fuel poor are

\textsuperscript{62} The equivalence of median ENEX for Direct Debit and PPM could not be rejected in 2014. Focusing on 2013 and 2014 ensures comparisons do not depend on the PPM correction. The gap between PPM and Direct Debit ENEX was noticeably higher between 1998-99 and 2005-06.
those for whom energy services, especially heat, are deemed unaffordable. Section 5’s results raise additional questions as to whether it is useful treating FP as distinct from general poverty.

**FP Strategy (FPS)**

Rather than considering individual FP alleviation policies, we use governments’ FPS and the choice of FP statistics to indicate the emphasis given to this issue. As with transfer payments the striking feature of FPS is its timing means it does not appear to be a response to increasing affordability pressures: the first FPS was introduced in 2001 near the low point in median ENEXShr (see Figure 13).

![Figure 13 – FP Policy Developments Mapped Against Indices of ENEXShr](image)

The very first steps leading towards FP as a distinct policy arena did occur during high energy affordability pressures: the late 1970s and early 1980s. The first citation for FP is Isherwood and Hancock (1979) and in 1981 the NGO National Energy Action (NEA) was founded. However, the growing political awareness of FP following the publication of Boardman (1991) occurs against a backdrop of falling ENEXShr. In 1995 the All Party Parliamentary Warm Homes Group was established, while in 1999 the government established a UK Inter-Ministerial Group on Fuel Poverty. While reducing FP is mentioned in Labour’s 2001 election manifesto, Kidson and Norris (undated) note a formal FPS resulted from an earlier Private Members Bill introduced to Parliament by the Conservative MP David Amess. Kidson and Norris explain the resulting Warm Homes and Energy Conservation Bill gave the government one year to produce a strategy explaining how the aim of ending FP within 15 years would be achieved. Following strong support in Parliament, the government supported the bill and the Warm Homes and Energy Conservation Act was passed in 2000. Agreeing to introduce a FPS at a time of historically low ENEX would be a nagging problem for successive governments as ENEX rose.

The main story emerging from Figure 13 is how rising ENEXShr after 2003-04 made substantially reducing FP increasingly challenging/costly. Where the Westminster government was in control, i.e. in England, this ultimately led to a less ambitious but likely more achievable FP target; however, prior to this, the official FP definition was altered in a way that might be seen as an attempt to define away

---

63 The detail on development in FP policy borrows heavily from the timeline on pg 5-9, NEA (2016).

64 “Fuel poverty blights lives: our aim is that by 2010 no vulnerable household in the UK need risk ill-health due to a cold home”, pg 13, ‘Ambitions for Britain – Labour’s manifesto 2001’, available at: http://www.politicsresources.net/area/uk/e01/man/lab/ENG1.pdf

65 The bill’s first reading had 143 votes in favour and none against.
the problem. In the case of FPS rising affordability pressures appear associated with a decrease in policy ambition as much as increased policy action.

When the Labour government published its FPS in 2001 the objective was:

“In England, the Government as far as reasonably practicable will seek an end to fuel poverty for vulnerable households by 2010.

Fuel poverty in other households in England will, as far as reasonably practicable, also be tackled as progress is made on these groups, with a target that by 22 November 2016 no person in England should have to live in fuel poverty.”

While the target contains the get out clause “as far as reasonably practicable”, it is clear that a failure to reduce FP would be politically embarrassing. At the same time an ‘absolute’ definition was chosen for the FP statistic, i.e. FP was defined against a fixed threshold rather than linked to the ENEX of an ‘average’ household. A fuel poor household was defined as one where ENEX exceeded 10% of household income. The consequence of choosing an absolute rather than relative FP definition is that absolute FP statistics are more sensitive to energy price and ENEX fluctuations. Figure 14 shows that as ENEX rose between 2003-04 and 2009 the official FP rate rose from 5.9% to 18.4%. Despite an FPS and policy initiatives to reduce FP the simplistic message given by the official FP statistics alone was that the government had failed abjectly.

In March 2011 the new Coalition government initiated an independent review of FP leading to the Hills Report (2012). The Hills Report’s key recommendation was that a new ‘Low Income High Cost’ (LIHC) FP definition be adopted. This considerably more complex definition did address legitimate critiques of the previous definition, primarily that high income households could be classed as fuel poor. However, as significant was that the new metric was relative: a fuel poor household had to have high energy costs relative to average households and low income relative to average households. Figure 14 shows this definitional change had a three effects on the official headline FP rate:

(i) the FP rate dropped at the date of the change;
(ii) the FP rate became very stable through time;
(iii) the relative nature of the metric makes FP eradication very challenging.

While Hills (2012) provides a range of arguments to favour the LIHC metric, the movements of the two statistics in Figure 14 might support a more cynical interpretation of government’s choice of metric being influenced by political expediency. At the end of the 10% metric time series, the headline FP it provides is 3.5 percentage points above that of the new LIHC metric. That the LIHC metric has a range of only 1.5 percentage points compared to 12.5 percentage points for the 10% metric might also be politically advantageous with it being harder for the media to produce striking headlines from the FP statistics. What is certain is the lack of variation in the LIHC metric limits the information it conveys as

66 See pg 7, DEFRA (2004). At the outset responsibility for target setting in Wales, Scotland and Northern Ireland was left to the devolved administrations, hence, the evolution of their strategies, targets and statistics is not discussed here.
67 The desire to ensure high income households are never classed as fuel poor does not automatically lead to the LIHC metric, for example, one could look at the percentage of those in the bottom half of the income distribution who spend more than 10% of their income on energy.
68 See Appendix 2 for additional detail.
69 While the LIHC metric lies above the 10% metric when the 10% metric was introduced in 2003-04, it is unclear that the LIHC metric was known about prior to Hills (2012).
an energy affordability indicator, although this stability might help the targeting of FP policies. Hills (2012) does create a second indicator, the Fuel Poverty Gap\textsuperscript{70}, that is sensitive to energy price fluctuations, however, as the FP Gap is a second statistic its salience in media coverage may be limited.

Following the change in FP definition, in 2015 a new FPS was published containing a softer target, although, one that was far more realistic. The 2015 FPS states:

“The fuel poverty target is to ensure that as many fuel poor homes as is reasonably practicable achieve a minimum energy efficiency rating of Band C, by 2030”\textsuperscript{72}

Significantly this target is based on an energy efficiency rating than an outcome linked to a householders’ lived experience such as ENEX or their perception of heat affordability. While focusing on energy efficiency improvements is potentially sensible, the relevance of this target to welfare improvements is reliant on improvements in energy efficiency ratings being strongly correlated with householders’ lived experience. The government can demonstrate good performance against this target simply by installing energy efficiency equipment without demonstrating that these installations deliver real benefit to householders.

7. FP Metrics – Actual vs Required Expenditures

The reliance on dwelling energy performance modelling in FP assessments is not new as official FP statistics have been based on \textit{required} rather than actual ENEX since their introduction. An argument put forward for this is that actual ENEX will under-report true FP as households who find energy affordability most challenging will reduce energy consumption. However, as Hills (2012)\textsuperscript{73}, Moore

\textsuperscript{70} The FP Gap is the reduction in energy costs required to take a household out of LIHC FP. The FP Gap is reported as an average per FP household and as a population aggregate.


\textsuperscript{72} See HM Government (2015).

\textsuperscript{73} See pg 12-13.
Draft – Please do not cite without permission

(2012) and Thomson et al (forthcoming) note, relying on modelling to estimate required ENEX has weaknesses due its reliance on assumptions. The assumptions include:

- the temperature to which individuals heat their home
- the pattern of heating, occupancy and energy consumption
- the energy prices paid by consumers
- how dwelling characteristics affect the cost of reaching a particular temperature.

To truly assess how modelled ENEX departs from actual ENEX studies are needed combining both information on housing characteristics, as in the English Housing Survey (EHS), and ENEX data from the same households. While we do not have this data, our ENEX data can be used to calculate FP rates based on actual ENEX which can be compared with official FP rates over several years to make inferences about the potential extent of discrepancies. This ability to compare FP statistics through time means the present work complements that of BRE (2013). The results indicate a far more complex relationship between FP statistics based on actual and required ENEX than just that actual ENEX results in an under-reporting of FP. Actual ENEX produces consistently higher FP rates for certain groups, most notably those in social housing.

At the outset we accept that differences in the definitions and methodology between the EHS and LCF, along with the implications of the PPM imputation, mean that our results are not the final word on comparisons of FP rates using actual and required ENEX. However, the findings do raise specific questions that warrant further investigation. One issue is the extent to which existing research comparing actual ENEX from the LCF against required ENEX is affected by the PPM data issue. PPM households are likely to correlate closely to households which required ENEX classifies as fuel poor. Appendix 2 provides detail on the extent to which our FP calculations match the official FP methodology. All FP statistics relate solely to English data.

One benefit of using actual ENEX data is FP rates can be estimated for a longer time period than the official statistics. Figure 15 shows the LIHC metric’s relative stability through time is repeated when using actual ENEX. The range of actual ENEX FP rates using the 10% metric is 10.6 percentage points, but only 2.1 percentage points with the LIHC metric.

Figure 15’s most interesting feature is the variation in the 10% metric when using actual and required ENEX. When median ENEX is low (see Figure A3.5) the actual ENEX FP rate is above that for required ENEX, but when median ENEX is high the actual ENEX FP rate tends to be below that for required ENEX. A possible explanation is that required ENEX is based on a fixed consumption level, while actual ENEX reflects consumption variations. When energy prices are high one would expect households to reduce energy consumption, thus holding down actual ENEX, while when energy prices are low households might increase their energy consumption limiting the fall in actual ENEX. If one wishes FP statistics to pick up the welfare effects of fluctuating energy prices this evidence is consistent with a 10% metric based on required ENEX having advantages over one based on actual ENEX.
When considering FP statistics by household type the relationship between actual and required ENEX is more complex. This is unsurprising if the modelling of required energy consumption leads to estimates which are most accurate for ‘average’ households. The results that raise the most concerns about required ENEX modelling are FP rates by tenure. Figure 16 shows that the actual ENEX FP rate for social housing is consistently above that using required ENEX directly contradicting the FP literature’s intuition that actual ENEX leads to FP being under-reported. Figure 16 shows the difference in FP rates is large being above 8 percentage points with the exception of 2009 and 2010. That actual ENEX FP exceeds required ENEX FP for those in social housing is repeated for the LIHC metric in Figure A2.1.

Figure 16 also shows the gap between social housing tenants’ and owner occupiers’ FP rates is much wider when using actual ENEX. This finding is consistent with two concerns about the methodology producing required ENEX. The first, and more serious issue, is that investments in the social housing stock, including increasing its energy efficiency, might not be delivering real benefits for occupants. Installing energy efficiency technology mechanically lowers required ENEX regardless of the technology’s actual performance. Figure A2.2 provides evidence consistent with this concern being real: it shows the average energy efficiency rating of social housing is persistently higher than for owner occupiers. This, combined with lower incomes for those in social housing, suggests the social housing FP rate will be particularly sensitive to errors when estimating energy requirements. The second possibility is the average energy prices used to calculate required ENEX are lower than the prices being paid by social housing tenants. This is a real possibility since the CMA found these tenants to be less likely to have switched suppliers so they are more likely to be on higher price default and PPM tariffs.

---

74 FP statistics are not calculated prior to 1995-96 due to uncertainty about the recording of Council Tax expenditures prior to this date.

75 Corroborating our argument BRE (2013) reports that ‘underspending’ was less likely among households with higher SAP ratings.
As noted above the correlation between social housing and PPM use means that impact of the PPM imputation must be recognised. Figures A2.3 and A2.4 show that PPM users’ actual ENEX FP rate consistently exceeds official FP statistics. The first potential impact of the imputation, compared to the true ENEX distribution for PPM users is that the variance in our data with imputation applied will be lower as the imputed values do not include ‘randomness’. If this issue has an impact on the actual ENEX FP rates reported it likely decreases the FP rate compared to their true values since FP statistics look at the ENEX distribution’s upper tail and an increase in the variance of ENEX would extend these tails. This would reinforce the argument that actual ENEX does not necessarily under-report FP. However, acting in the opposite direction is that by imputing expenditure for all PPM consumers recording zero PPM expenditure, our ENEX values are upper bounds potentially inflating our actual ENEX FP rates. Yet this second issue should not be overplayed. Figure A2.1 shows that in 2013 and 2014, when no imputation occurred, the actual ENEX FP rate was around 14 percentage points higher than the required ENEX FP rate.

The relationships between actual and required ENEX FP rates broken down by other household characteristics are generally mixed and more challenging to interpret. One exception to this is the breakdown by household composition. Figure 17 shows that for families with 2 adults there is little difference between the actual and required ENEX FP rates, but the actual ENEX FP rate for single parent households is elevated for the 10% metric. The actual ENEX FP rate for single parent households is between 5.1 and 15 percentage points above the required ENEX rate. Figure A2.5 shows this relationship is repeated for the LIHC metric, although, the gap is noticeably smaller being on average 4.2 percentage points compared to 11.3 percentage points under the 10% Metric. Findings

---

*Since the 10% Metric is an ‘absolute’ threshold the impact of an increase in variance is straightforward. An increase in variance is likely to increase FP under the LIHC metric because ‘Low Income’ is defined as income after the deduction of ENEX compared against an income threshold that does not deduct ENEX.*

*An alternative critique is that LCF respondents may exclude particularly vulnerable or financially constrained households. While this may be true it is unlikely to explain the difference in actual and required ENEX FP rates since the EHS is also an in-depth survey likely to suffer from response issues.*
for social housing, PPM users and single parent households are probably linked due to the overlap in the sampled households which belong to these three groups.

![10% Metric Fuel Poverty by Selected Household Compositions, Actual v Required Energy Expenditures](image)

**Figure 17 – 10% Metric FP Rates for Single and Two Parent Families, Actual vs Required ENEX**

When looking at results by income decile conclusions are restricted by the limited number of years for which official statistics could be found: 2 years for the 10% metric and 4 years for the LIHC metric (see Figure A2.6). Under the 10% metric actual ENEX leads to a lower FP rate in the lowest and 4th income deciles, but higher FP rates in the 5th decile and 6-10th deciles combined. The relationship for the 2nd and 3rd deciles varies by year, while the gaps for the 5th decile and 6-10th deciles combined appear small. When using the LIHC metric actual ENEX leads to higher FP rates in the 1st and 2nd income deciles (Figure A2.7). FP rates by the age of the oldest household member is even more mixed with whether actual or required ENEX FP rates are higher generally varying by year. Using the 10% metric, only for households with an oldest member aged 75+ does a potentially consistent relationship through time emerge, with the required ENEX FP rate being higher in every year apart from 2004-05 (Figures A2.8). However, this relationship is not replicated for the LIHC metric (Figure 2.9). That the 10% metric indicates households in the lowest income decile and containing someone aged over 75 have higher required ENEX FP rates is some evidence that these households spend less on energy than expected. While this could be due to these households restricting their energy consumption due to budget pressures, it equally might be due to assumptions used to calculate required ENEX being false.

The current paper is not the first to compare actual and required ENEX in the UK. In methodological terms the closest analysis is contained in the official annual FP reports DECC (2013) and DECC (2015)79, and in Hirsch et al (2011). Together DECC (2013) and DECC (2015) compare actual and required ENEX by income decile in 2012 and 2013. The considerable differences between 2012 and 2013 reflect the change in the LCF’s energy questions between these years. For example, DECC (2013) reports that in 2012 average modelled ENEX in the bottom income decile was 33% above actual ENEX and that even by the 8th income decile this gap was 10%. However, DECC (2015) reports that in 2013 actual ENEX was very close to modelled ENEX, with average modelled ENEX for the bottom income decile being

---

78 Under the LIHC metric in all but one year the actual ENEX FP rate is higher for households in the 25-34 category, while for households in the 50-59 category in every year required ENEX FP is higher.

79 See Table 8.1 on pg82 in DECC (2015) and Table 9.1 on pg 73 in DECC (2013).
only 4% above average actual ENEX. Indeed, DECC (2015) finds that in seven income deciles average actual ENEX were above average modelled ENEX. In the top income decile average actual ENEX was 12% above average modelled ENEX. These difference highlight the importance of applying the PPM correction when comparing actual and required ENEX; not applying the correction will overestimate the extent that required ENEX exceeds actual ENEX. In turn, not applying the correction may lead to inferences that overplay the extent of ‘underheating’ among groups, such as those on low incomes, with high PPM use.

Hirsch et al (2011) appear to employ a more sophisticated analysis than DECC (2013) and DECC (2015) as they utilise a synthesised dataset combining LCF data from 2004 to 2007 with the 2007 English Housing Condition Survey. However, given the LCF data used, it is likely that Hirsch et al’s conclusions emphasising household underspending will, in part, result from the PPM data issue. As with the literature on CO2 emissions, the ‘consumption’ data in Hirsch et al (2011) is via a manipulation of LCF expenditure data and so will also be affected by the PPM data issue.

A methodology avoiding the PPM data issue is followed in BRE (2013) where actual and required fuel expenditures were compared for roughly 1,300 households following a specific data collection exercise in 2011. This study found that around two-thirds of households underspent compared to modelled ENEX, however, the detail of the results supports our argument that the superiority of required over actual ENEX is not obvious. For example, BRE (2013) reports that while 80% of LIHC FP households were ‘underspending’, so were 65% of non-FP households suggesting modelled ENEX is systematically overestimating actual ENEX. Furthermore low income households are reported as being as likely as high income households to underspend. Also, actual ENEX of those not underspending was found to be on average 50% above modelled ENEX80. While BRE (2013) finds that ‘underspending’ households have lower average internal temperatures this correlation does not address the core question: are households choosing lower temperatures by choice or are they forced to accept lower temperatures due to budget pressures? Nevertheless, value of further research in this area suggests that Moore’s (2012) recommendation that the collection of actual energy consumption and expenditure data be re-introduced into the EHS is a sensible one.

8. Appendices

Appendix 1 – Evidence for treating PPM ‘zeros’ as missing data

Our view that the PPM zero ENEX should be treated as missing data is based on a range of evidence. First, Figure A1.1 shows the sharp increase in median ENEX for PPM consumers between 2012 and 2013 is neither replicated for other payment methods nor in average pricing data for PPMs. Raw survey data is used in Figure A1.1 to exclude the possibility that any of the treatments applied to the data influence the movements between 2012 and 2013.

80 See Table 1, pg5, BRE (2013).
While median ENEX for PPM users increased 127% between 2012 and 2013, the increase for those paying by Arrears or Direct Debit was only 4-4.5%. Similarly, ‘BEIS PPM medium consumption’, the energy bill resulting from a constant level of consumption and PPM tariffs sampled from energy firms, shows an increase of only 3.3%.²¹ Thus the change in PPM users’ median ENEX does not result from price changes or factors affecting the energy market in general.

Second, Advani et al’s implicit assumption that PPM consumers generally top-up less frequently than once every two weeks is directly contradicted by survey evidence from Electricity Association (2001) and Mummery and Reilly (2010). Electricity Association (2001) reports that for households within 1 mile of a top-up point 76% of electricity and 72% of gas consumers topped up on a weekly basis.²² Using more recent data Mummery and Reilly (2010) report that “Two-thirds of PPM households topped up their meter at least once in a typical week”.²³ That a sizeable majority of PPM consumers report topping up on a weekly basis suggests that only a small percentage of households top-up less frequently than once every two weeks.

A related point, often highlighted in the FP literature, is that PPM users ‘self-disconnect’, i.e. they deliberately choose not to top up and let their energy supply stop to economise. However, the survey evidence again suggests this behaviour is unlikely to explain the PPM data issue as self-disconnection is relatively rarely and lasts for short periods of time. Electricity Association (2001) reports 24% of electricity PPM users had self-disconnected at some point in the previous year and of these

---

\[²¹\] Data for ‘BEIS PPM medium consumption’ comes from summing the relevant columns of Table 2.2.1 and Table 2.3.1 of BEIS (2017). Electricity expenditure is based on consumption of 3,800kWh/year. Gas expenditure is based on consumption of 15,000kWh/year. For further methodological information see: ‘Domestic Energy Prices: Data sources and methodology’, available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/579391/Domestic_Energy_Prices_-_updated_Dec_2016.pdf

\[²²\] See Tables 5.12 and 5.13 of Electricity Association (2001). Even for the small number of households more than 3 miles from a top-up point 67% of electricity and 63% of gas consumers topped up on a weekly basis.

\[²³\] See ‘Topping-up the meter’, pg 14, Mummery and Reilly (2010).
households 42% (28% for gas) had done so only once. Mummery and Reilly (2010) is clearer still: they report only 16% of PPM households had self-disconnected in the previous year, with half of this group doing so only once or twice. More significantly, for the PPM data issue, Mummery and Reilly report that periods of self-disconnection generally lasted hours rather than days: only 9% of those who self-disconnected typically did so for more than 24 hours and only 1% typically disconnected for two days or more.84

Third, there appears to be only limited seasonality in the percentage of observations which are zeros. If zero expenditures were due to infrequent top-ups, it seems plausible that lower heating requirements in summer months would mean a given top-up lasting longer and top-ups would be less frequent leading to a greater frequency of zeros being recorded in summer months. Figure A1.2 reports the proportion of PPM users reporting zero expenditure according to their interview month averaged across 2001-02 to 2012.85 Figure A1.2 shows some evidence of seasonality, particularly in relation to gas PPM users between May and August. This suggests that for some survey participants interviewed in the spring and summer, the explanation for zero expenditures is infrequent topping-up. The key point for our argument is the proportion of ‘seasonal’ zeros appears to be a small proportion of all the zeros observed across the year. Even in winter months around 45% of PPM consumers report zero expenditure on the relevant fuel; compared to this baseline the percentage of gas PPM zeros increases by roughly 5-7 percentage points for six months of the year and by 10-15 percentage points for two months of the year.

![Proportion of PPM consumers reporting 'zero' expenditure for relevant fuel by interview month](image)

**Figure A1.2** – Percentage of PPM Users Reporting ‘Zero’ Expenditure for Relevant Fuel by Interview Month, Averaged over 2001-02 to 2012

Figure A1.3 shows the impact of the PPM correction where fully adjusted median ENEX is reported alongside the median PPM ENEX from the raw data. The corrected PPM time series features movements that broadly match those for Direct Debit and Arrears ENEX. In particular, the corrected

---

84 Vyas (2014) report results broadly consistent with Mummery and Reilly from a similar survey conducted in 2013-14.

85 This covers the period when the highest rates of zeros were being recorded (see Figure 1).
PPM median ENEX increases by 9.4% between 2012 and 2013 which is close to that for Arrears and Direct Debit (7.2% and 7.1% respectively).

Figure A1.3 – Median ENEX by Electricity Payment Method

Appendix 2 – FP Statistics

Official FP Definitions

DECC/BRE (2016) provide a detailed description of the methodology behind the official FP statistics.

**10% Metric** The definition of the 10% Metric is straightforward, a household is fuel poor if the value of the following ratio exceeds 0.1:

\[
FP \text{ Ratio} = \frac{\text{Required Fuel Costs}}{\text{Income}}
\]

i.e. a household spending more than 10% of its income on energy is deemed fuel poor. Income is net of tax and benefits.

**LIHC Metric** The definition of the LIHC Metric is more complex involving two thresholds. A household is fuel poor if both of the following statements hold:

1. Required fuel costs are above the national median

AND

2. Income remaining after the deduction of required fuel costs is below the official poverty line.

Here income is net income after the deduction of housing costs and equilatisation where housing costs are restricted to mortgage and rent payments. The official poverty line is defined as 60% of median equilised disposable income. When calculating the LIHC Metric required fuel costs are also equilised using a different equilisation factor to that for income. The equilisation of fuel costs

86 The after housing costs equilisation factors are provided in Table 10, pg 50, DECC/BRE (2016)

87 In calculating the official LIHC FP statistic this is taken to be equilised after housing costs net income.
appears to account for economies of scale in energy use when a household has a large number of members.

The official FP statistics are based on EHS data which combines a household interview with a detailed physical survey for around 6,000 households. Required energy use is built up from estimates for four different uses: space heating, water heating, lights and appliances, and cooking. Estimated energy requirements are based on the detailed dwelling information collected in the EHS.

To understand why required ENEX may differ from actual ENEX it is worth highlighting some of the modelling assumptions. Most significantly it is assumed that a primary zone in a dwelling is heated to 21°C and a secondary zone is heated to 18°C. It is assumed that for particularly large properties (relative to number of occupiers) only half of the dwelling is heated. Also, it is assumed that heating is only used between October and May. The standard assumed weekly heating regime reflects 9-to-5 working patterns with 2 hours of heating each morning and 7 hours from late afternoon onwards, while at the weekend heating is assumed to be on for 16 hours each day. For households where someone is in the dwelling throughout the week it is assumed that every day involves 16 hours of heating.

Given the large number of fixed assumptions in the heating regime compared to the variable behaviour and preferences of individual households, it is unsurprising that actual ENEX often departs from required ENEX. This means it seems a strong assumption to interpret the gap between required and actual ENEX as a measurement of the extent of under-heating due to affordability pressures.

The energy requirements for water heating, lighting and cooking are based on equations incorporating various household and dwelling characteristics. If has house has gas and electric connections it is always assumed that cooking requirements are split equally between gas and electricity.

Once the required energy consumption has been calculated it is multiplied by energy prices. The energy price used is the regional average for the payment method of the surveyed household, based on quarterly tariff data provided by energy companies.

**FP Statistics Using Actual ENEX**

When calculating actual ENEX FP statistics an attempt has been made to follow closely the official methodologies. The same methods and broad definitions for variables as detailed above have been used. In particular, while the general ENEXShr reported in this paper use a high-level ‘Housing Costs’ variable taken directly from the LCF, for the actual ENEX FP statistics housing costs are restricted to rent and mortgage payments. As the official FP statistics relate to England, households in the devolved administrations in the LCF data are excluded.

While the intention is that the only difference between the official FP statistics and the actual ENEX FP statistics is the replacement of ‘Required Fuel Costs’ with ‘Actual ENEX’, we cannot guarantee that this is the case. The EHS and LCF are different surveys with different methodologies which may impact on the comparisons. In particular, the official FP statistics for any given year combine data from two consecutive waves (years) of EHS data. Also, there may remain discrepancies in the very detailed construction of the variables used to calculate the official and actual ENEX FP statistics.
FP Time Series

**Figure A2.1** – LIHC Metric FP Rates by Tenure, Actual vs Required ENEX

**Figure A2.2** – Average Energy Efficiency (SAP Rating) by Tenure, 2001-2012 (Figure 1.1 in DCLG, 2014)
Figure A2.3 – 10% Metric FP Rates by Electricity Payment Method, Actual vs Reported ENEX

Figure A2.4 – LIHC Metric FP Rates by Electricity Payment Method, Actual vs Reported ENEX
Figure A2.5 – 10% Metric FP Rates for Single and Two Parent Families, Actual vs Required ENEX

Figure A2.6 – 10% Metric FP Rates by Selected Income Decile, Actual vs Required ENEX
**Figure A2.7** — LIHC Metric FP Rates by Selected Income Decile, Actual vs Required ENEX

**Figure A2.8** — 10% Metric FP Rates for Selected Age Groups, Actual vs Required ENEX
Our imputation method for the PPM data issue implies the estimated ENEX and ENEXShr distributions show less variation than if true PPM ENEX had been observed as the imputed values lack randomness. While the distributions reported in Figures A3.1 to A3.5 are compressed to some extent, this point should not be overplayed as no more than 10% of households have imputed ENEX in any given year.
Figure A3.2 – Equivalised After Housing Costs ENEX Shr for Selected Years

Figure A3.3 - Equivalised After Housing Costs ENEX Shr, 1992-2014
Figure A3.4 – Household ENEX in Real Terms, 1977-2012

Figure A3.5 – Household ENEX in Real Terms, 1992-2014
Figure A3.6 – Index of Average Energy Consumption per Household, 1992-2015

Figure A3.7 – Median ENEX by Age of Household Head, 2014 Prices

89 This data is from Table 3.04 in Energy Consumption in the UK (ECUK) 2016 Data Tables published by the Department for Business, Energy and Industrial Strategy at: https://www.gov.uk/government/statistics/energy-consumption-in-the-uk.
Figure A3.8 – Median ENEX for Selected Household Compositions, 2014 Prices

Figure A3.9 – Median ENEX by Household Tenure, 2014 Prices
8. References


\*90 That the median ENEX of households with gas fired central heating are higher than for those with electric central heating probably relates to the type of properties which have each type of central heating: large houses are likely to use gas, while smaller flats use electricity.

Chatterton, T.J., J. Anable, J. Barnes and G. Yeboah (2016), ‘Mapping household direct energy consumption in the United Kingdom to provide a new perspective on energy justice’, Energy Research and Social Science, 18, pp. 71-87


Mummery, H. and H, Reilly (2010), ‘Cutting back, cutting down, cutting off – Self-disconnection among prepayment meter users’, Consumer Focus, July 2010, London, United Kingdom


Thomson, H., S. Bouzarovski and C. Snell (forthcoming), ‘Rethinking the measurement of energy poverty in Europe: A critical analysis of indicators and data’, Indoor and Built Environment


Waddams, C. and D. Deller (2015), ‘Affordability of utilities’ services: extent, practice, policy’, a report for the Centre on Regulation in Europe (CERRE), Brussels, Belgium