DEPARTMENT OF ENERGY & CLIMATE CHANGE

RESEARCH REPORT

Empowering Households - Research on presenting energy consumption benchmarks on energy bills

Undertaken by Ipsos MORI

The views expressed in this report are those of the authors, not necessarily those of the Department of Energy and Climate Change (nor do they reflect Government policy).

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Introduction

The Department for Energy and Climate Change commissioned Ipsos MORI to conduct research on the potential for including energy consumption benchmarking data on energy bills. These benchmarks would provide consumers with comparative information on the energy consumption levels of other households. The overall aim of the research was to create credible benchmarks for consumers and test consumer preferences and likelihood to respond to this type of information.

The research comprised 49 in-depth in-home interviews with consumers to test their attitudes and preferences, and statistical analysis of electricity and gas consumption data across Great Britain to create credible benchmarks. The interviews were conducted in six locations across the UK and represented a mix of people in different types of property, household compositions, lifestages, incomes, tenure, and payment models.

Options for presenting benchmarking information were tested with all 49 consumers who participated in the in-home interviews. To inform the design and focus of these options, some preliminary research was also conducted: a review of existing evidence on benchmarking data and six discussion groups with consumers. A summary of the findings from the preliminary research can be found in section 1.5 of the report. Detailed findings from the review of existing evidence are contained in appendix D.

The research found that providing benchmarking data is likely to encourage greater interest in bills and levels of consumption. However, the research was limited in the extent to which it can reveal the likely impact of benchmarking data on actual consumption behaviours. The findings presented below are the result of a relatively small qualitative sample. In addition, participants were asked hypothetically how they might respond to benchmark information, and we cannot be sure they would in fact respond this way if they received the information. For a robust conclusion on whether presenting benchmarks could lead to changes in energy use, a trial testing actual behaviour would be needed.

Research findings

In summary, the research found there was an appetite across all consumer groups interviewed for an energy consumption benchmark to be included within their bills. This included interest from those on pre-payment meters. Those who were not interested in receiving benchmarking information tended to be ambivalent about how they might use the information, rather than directly oppose the concept itself.

After testing a number of options, the research concluded that the most appropriate type of benchmark to present on consumer bills is likely to be based on median energy use (50th percentile) for that local area.

Attitudes to energy consumption and billing

The research showed that participants did not tend to engage with their bill in its present form, and only checked the document to see how much they have paid/ have to pay and to confirm the accuracy of meter readings. However, when introduced to the concept of an energy consumption benchmark, participants felt that its inclusion may make them engage with energy bills to a greater extent.

Reaction towards energy consumption benchmarks

Most participants welcomed consumption benchmarks on their bills and were interested in receiving this information. However, their initial reaction was to question the price they paid for their energy and to consider whether they were on the best tariff rather than question their own energy consumption behaviour. However, the research suggests there is potential for this increased engagement with energy bills to lead to other behaviour change.

Participants expressed a range of reactions to the inclusion of a consumption benchmark within their bill:

- Only a few participants (typically high energy users) spontaneously said they would find a benchmark motivating enough to change their energy consumption behaviour.

- Most participants felt it would be a useful starting point for increasing awareness of their energy usage.

- In contrast, others were sceptical about the impact of the benchmarks, as they felt key factors such as lifestyle, age of house and the number of people in a household, were not taken into consideration. These participants would not, however, be hostile to receiving a benchmark on their bill but would be less likely to take notice of it.

Impact of energy consumption benchmarks

The research showed that the potential impact of the benchmark was dependent on a number of factors including the visibility of the information, its perceived credibility, the extent to which their bill differed from the benchmark and the proportion of the household income spent on energy bills.

- **Visibility of the benchmark**– Participants stressed that the benchmark would need to be prominent in the bill, preferably just under or next to the bill amount, in order for it to have maximum impact. It was felt the benchmark should be based on annual usage or spend figures as this would have a greater impact than monthly figures.

- **Credibility of benchmarks** - The credibility of the information was enhanced for participants by explaining the term ‘average household’. Participants wanted the benchmark to be focused on as localised an area as possible to help them understand the information and to allow them to more readily compare themselves against it. Some also suggested that association or endorsement from an official source, such as the government or a watchdog, would provide greater credibility.

- **Comparing a household’s usage against the benchmark** - Participants tended to react in different ways depending on their circumstances and the amount of difference between their usage and the benchmark. This research found that the benchmarks might only encourage behaviour change amongst those whose bills were substantially higher than the benchmark. Initially, any action is likely to be restricted to investigating cheaper tariffs or alternate suppliers to see if they could lower their bills. A few respondents said that if they switched tariff, and their bill remained substantially higher than the benchmark, they might then consider how to reduce their energy use.

- **Bill as a proportion of household income** - For households where the energy budget was a smaller portion of their overall income, saving money on their bills was seldom considered a priority. On the other hand, participants from households with a smaller income said they were more likely to engage with any information that they thought would help them save money.

The reactions to the benchmark data presented suggested that its impact would most likely be determined by two variables – household income and the size of the difference between the household's energy bill and the area's benchmark. In addition, this research found that other factors, such as financial behaviour, home ownership and concern for the environment could affect the impact of the information on participants. No differences were found in the likely impact of a consumption benchmark for participants living in different types of area. It was hypothesised that the visible homogeneity, or heterogeneity, of an area could affect the credibility of information given for an 'average household in the local area'. However, this factor did not seem to impact on views in this study.

This research suggested that the provision of an energy consumption, or spend, benchmark is **unlikely to have a negative effect on low income pre-payment meter users**[1]. Participants on pre-payment meters had a high awareness of how little energy they use and how it fell short of their needs. They stressed that their level of consumption was dependent on their overall financial circumstances rather than the desire to consume less energy. However, while the views of low-consuming households captured through these interviews were universal on this front, only 10 of these participants were interviewed in this research, thus findings cannot be generalised. Other studies[2] have shown that low-consuming households may indeed increase their energy use after receiving benchmark data. Understanding the precise response among this group would require further longer term research such as a trial.

Presentation styles for benchmarks

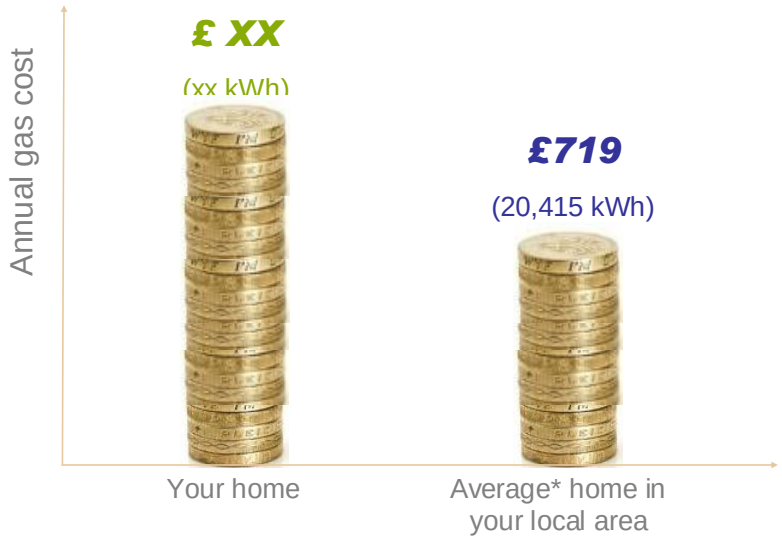
Participants were shown different ways of the benchmark being presented to them on their bills. Some of these presentations were in simple text format, while others used charts. This research showed that participants needed relevant and credible benchmarks to be able to engage with the issue of energy consumption. This could be achieved through appropriate placement of the information and by using terms that were understood.

The preferred presentation for benchmark data within a consumer bill has been developed from preferences expressed. This is shown in Figure 1 below.

[1]The responses of low income PPM customers are used as a proxy for the attitude of the 'fuel poor'. These householders tend to use below the average level of energy in their area .These customers may or may not be officially defined as living in fuel poverty . Customers living in fuel poverty are challenging to recruit for research given the need to request sensitive details upfront about their total household income and their fuel bill payments. A request of this nature typically receives a low acceptance rate for interviews and the timetable for this fieldwork precluded this as an option for recruitment.

[2] See appendix D: Review of existing literature

Figure 1: Preferred presentation of benchmark within consumer bill



* An average home in your local area is considered to be a 4 bedroom house with 5 occupants

Save £50 per year by turning your thermostat down by 1ºC rather than opening windows.

For advice on how to reduce your gas consumption go to **website@address** or call the **Energy Savings Trust** free on **0800 512 012**

The research pointed towards the following recommendations for the placement and presentation of benchmark data.

- Benchmark data should be included on the front page of the bill, ideally alongside the bill amount. Participants said this would ensure they see the benchmark data, as they were very unlikely to look beyond the first page, and a direct comparison with the bill amount would help to maximise its impact.

- Participants found text-based information easy to understand, but preferred a bar chart format. They felt that their bills tended to contain a lot of information, and text-based information may not be read. Some participants found the use of visual imagery (such as coins) more engaging than blocked bars on a chart.

- Seeing the actual amount (i.e. with the symbol £) spent had a higher impact than units of energy consumption (kWh). This reflected participants' lack of familiarity with the term kWh and lack of understanding of the level of energy consumption reflected in a certain kWH usage.

- A format combining money and usage (i.e. includes both £ and kWh) was suggested as an optimal approach by some participants as it might increase the direct association of the amount spent with kWh consumed. If this option was not feasible, then the format that presented the amount (in £) alone was preferable.

- Participants found additional information, i.e. advice on reducing energy bills, a useful feature but thought information needed to vary across bills so that new information is given over time. Participants were confident about using web sites or free phone numbers as a starting point for their own research on how to reduce their gas and energy consumption but would like to see some of this information displayed within their bill. Particular interest was expressed in receiving information on the cost savings generated by certain behaviours, or by energy efficient appliances, so they could assess the case for taking these up or, in the case of appliances, purchasing them.

- Most participants were familiar and comfortable with using online tools, and thought it would be useful if there were such a tool available which included options for criteria such as; age of house, type of house, levels of insulation, double glazing etc. It was felt this would help increase their understanding of the 'average' consumption in a house similar to their own.

Type of benchmark

The participants involved in this research were presented with benchmarks based on average consumption data and percentile data. The reactions of participants to these different types of benchmark, as well as analysis of the gas and electricity (including both profile 1 and profile 2) meter-point datasets, were used to assess the most appropriate benchmark to include within consumer bills.

This research suggested that the most appropriate type of benchmark to present on consumer bills, is likely to be a **median energy use (50th percentile) for that local area**. This recommendation was based on the following findings:

- Participant understanding of an average energy spend/use was far higher than comprehension of percentile data (based on consumption levels for the 90th and 10th percentiles and the 80th and 20th percentiles).

- Participants were more likely to interpret the percentile data, on the most, and least, expensive gas bills in the local area, or the highest, and lowest, gas users in the area (see page 23 for mocked-up example) as information on the availability of different energy tariffs as opposed to different levels of household consumption.

- Providing participants with a percentile range encouraged them to consider their energy use to fall within an acceptable range for the area.

- There was a preference for the benchmark to be based on the local area as, based on local knowledge, it enabled them to consider for themselves the applicability of the comparison to their own household and lifestyle. Beyond making their own judgements about the credibility, and relevance of the benchmark, participants did not want further information on how it had been calculated to be included within the bill. Participants considered their bill as 'official communication' and therefore were unlikely to question the validity of the calculations.

- This research found that participants did not make a distinction between different forms of average (mean, median or mode). From a statistical perspective the recommendation is to use median data as a benchmark due to the distribution of the consumption values. Analysis of the meter point electricity and gas datasets showed the median to be more robust to outlying values than the mean or mode. The mode would not be appropriate given the nature of the dataset (an interval scale) where relatively few meter point values were the same. The analysis showed across all areas, a greater proportion of consumers were consuming above the median value, than above the mean value. In a large number of areas the mean was higher than the 60th percentile, particularly for Electricity consumption. Even in the case of consumers who fell below the median consumption value, a significant proportion were within 1,000 to 2,000 kWh of the median value (see distribution information on page 35-6.) Therefore, the median presents greater opportunity for behaviour change since the research with participants has shown the greater the

difference between the average value and a household's own consumption, the greater the likely impact of this data.

- A target level of consumption was not considered a suitable basis for a benchmark. Participants did not respond positively to the concept of target-setting based on benchmark energy consumption data. A few were more interested in the idea if they could set the target themselves and track their progress against it through their bills.

Based on the participant reactions captured through this research, and the statistical analyses conducted on the meter-point datasets, a suggested set of benchmarks have been produced and provided to DECC. These are based on local area median consumption values. Benchmarks have been produced for gas and electricity consumption, with separate benchmarks for profile 1 and profile 2 (Economy 7).

It should be noted that the research did not specifically cover off-gas grid areas.

Research background and objectives

1. Research background and objectives

1.1 Research background

Energy bills are changing, and these changes aim to empower energy consumers to have a better understanding of their bills and to have an impact on their behaviour. Providing greater levels of information through bills on energy consumption and tariffs has been an increasing trend from both government and regulators. The Government's Coalition Programme now contains a commitment that energy bills should inform participants on how their consumption compares to that of 'similar households'.

If the provision of this benchmark information is to achieve its ultimate aim of being a call to action to reduce household energy consumption, then it is vital that it is in the right format, style and tone to empower consumers.

The purpose of this research study was to inform decisions on how best to do this and the potential impact of these decisions on behaviours. This information could be one of a number of nudges required to change behaviour and help deliver a low carbon future for Britain.

1.2 Research objectives

The overall aim of this research was to create credible energy consumption benchmarks, and to inform energy suppliers and policy makers' approach to include this data on consumer bills. The benchmarks produced need to be credible for different groups of consumers. More specifically this research aimed to understand from participants:

- the extent to which the provision of benchmark data might lead them to reduce their use of energy, and to what extent they would consider installing energy efficiency measures;
- what additional information they required to be persuaded to reduce their energy consumption;
- the most preferred format for presenting benchmark consumption information;
- how to ensure the provision of benchmark information does not have a negative effect on low consuming groups by encouraging them to use even less energy; and
- the likely variation in behaviour across different groups, including PPM customers.

This report brings together the findings from research with the public and outputs of statistical analyses to make recommendations for the most appropriate benchmarks, and presentation options, to incorporate within consumer bills.

1.3 Methodology

In order to provide a recommendation on the most appropriate benchmarks to incorporate within consumer bills, this research involved the following stages:

In-depth in-home interviews – 49 in-depth interviews were conducted to test different types of benchmarks with individual participants. The benchmarks were presented through shortlisted presentation options based on the findings from preliminary research (see below). The benchmarks presented to participants were relevant for their specific local areas (calculated on energy usage data for surrounding 500-600 properties). These interviews explored the extent to which benchmark data was likely to have an impact on participants' attitudes and behaviours in relation to their domestic energy use.

The interviews were conducted in six locations across the UK. These areas were chosen based on two key factors derived from statistical analysis; the heterogeneity of the properties within an area and whether the average energy consumption of households in the area was higher, lower or as would be expected based on the characteristics of that area (based on property type and population demographics). Across the 49 interviews a wide range of participants were interviewed with controls on recruitment to ensure coverage of different types of property, household compositions, lifestages, incomes, tenure, and payment models.

The benchmark data tested with participants was based on gas meter point consumption data. Economy 7 and off-gas grid participants were therefore not included within this part of the research.[3]

Production of a set of benchmarks - meter-point gas and electricity data from every Lower Layer Super Output Area (LLSOA) or Intermediate Geographical Zone across Great Britain was used to produce a recommended set of benchmarks. This process included cleaning and editing the meter point data to remove anomalous figures, conducting regression analysis to establish the household factors most correlated with energy consumption (floor space, no. inhabitants etc), exploring the homogeneity of household energy consumption within each local area and analysing whether local areas are over or under-consuming at an average level based on the characteristics and lifestyles of households in that area.

Details of the methodology are included in the appendices. The key outputs are available in separate documents. These comprise:

- Final cleaned meter points level datasets for both gas and electricity consumption with flags identifying meter points above/below the LLSOA/IGZ median
- Median consumption benchmark statistics for all LLSOAs and IGZs in Great Britain - for both gas and the combined profile 1 and 2 electricity, along with individual benchmarks for profile 1 only and profile 2 only
- Summary statistics including the mean, variance and percentiles
- Expected median consumption estimates from the models along with a residual score (Actual minus expected)

[3] Within the timetable, only one consumption dataset could be prepared in time for the consumer research strand. A decision was taken to prioritise the gas consumption data given the higher proportion of household income spent on gas compared to electricity. It was hypothesised that participants may therefore be more engaged with their level of gas consumption and their ability to change this.

To inform the design and focus of the above two stages, the following preliminary research was conducted:

A review of existing literature - Research and trials previously conducted around consumer reactions to energy consumption benchmarks were reviewed. This review also considered evidence for effective messaging for encouraging attitudinal and behavioural change and the likely impact of energy benchmarks on consumer behaviour. To date a lot of this research has taken place outside of the UK, particularly in North America, although this review does draw on research conducted with UK consumers where possible.

The findings from this stage were used to inform the recruitment of participants for stages 2 and 3 and also to inform the stimulus material tested at Stage 2. The full written output of this review is included in this report as Appendix B.

Discussion groups with consumers – six ninety minute discussion groups were conducted with a range of participants to explore the concept of energy consumption benchmarks and to understand the most comprehensive ways of presenting numerical data through bills (including both charts and text-only versions).

The locations for these discussions were chosen to provide a range of rural, suburban and urban housing as well as a variation in the likely income levels among participants. This was a key factor given it tends to dictate many other factors relevant to energy use and engagement with energy bills such as payment type (PPM, Payment on demand –usually quarterly on receipt of bill or Direct Debit) and housing type.

The primary output from these discussions was a shortlist of presentation options based on participant preferences to use at Stage 3. Detailed feedback on each presentation option tested during Stage 2 is included as Appendix C.

A more detailed account of each stage, including recruitment details and locations for the consumer research and the technical aspects of the statistical analysis are included in Appendix A.

1.4 Presenting the findings

The main body of this report draws evidence from the 49 in-home in-depth interviews conducted with consumers. This main stage was key to understanding the likely reactions and impacts of an energy consumption benchmark contained within bills. These interviews mimicked, as far as possible, the initial reaction consumers may have to benchmark information contained within an energy bill by presenting it to participants with no prior explanation or contextual information.

This report also discusses the differences in levels of receptiveness to benchmark information across different groups of participants. Where differences are not drawn out this is because there were no clear differences between groups or because participants were universal in their views.

Of the 49 in-depth interviews half were conducted in homogenous areas; with very similar property types, and half were conducted in heterogeneous areas; where there is a great deal of variation between property types and ages. This was considered an important factor to incorporate in the research design as the visible homogeneity, or heterogeneity, of an area could affect the credibility of information given for an ‘average household in the local area’. However, the analysis of these findings has not shown this to be a factor differentiating between participants’ views, and therefore differences according to the area type do not feature in the main findings of the report.

1.5 Preliminary research – summary of findings

The **review of existing literature** examined previous research conducted around consumer reactions to energy consumption benchmarks and the likely impact of energy benchmarks on consumer behaviour. To date a lot of this research has taken place outside of the UK, particularly in North America, hence the value of this new piece of research among UK participants.

The full written output is provided in Appendix B but the key implications of the review for the focus and design of the consumer research stages are summarised below.

The review pointed to a need across the research programme to:

- test the most commonly understood form for conveying numeric data (e.g. percentages, percentiles, textual description);
- recruit participants for the initial group discussions according to their age and social grade as these factors are key influencers on participants' ability, and interest, in interpreting numeric data;
- recruit participants for the in-depth in-home interviews who are less likely to trust data which is provided to them (the review suggested this to be older people, women, those in lower social grades and with lower levels of education);
- explore trust in energy suppliers as the provider of benchmark information, including the steps which can be taken, perhaps through appropriate messaging and language, to overcome barriers related to lack of trust;
- omit any presentation designs which had received widespread negative feedback and misinterpretation in previous studies, but to include designs with limited testing or with inconclusive results in the context of UK participants.
- test the concept of goal-setting as this had been found to be effective in encouraging behaviour change among participants;
- test the benchmarks with householders who have a range of energy consumption behaviours;
- test the style, tone and language of any additional information which may accompany benchmark consumption data. (e.g. technical information to reassure participants of the validity of the data, information about how to change consumption behaviours).

Group discussions with consumers tested a wide range of presentation options based on a shortlist produced following the review of existing designs. The full range of options tested, and the reactions to each of these, is provided as Appendix C. The following feedback gathered on presenting numeric information to participants emerged from the group discussions.

- Across all participants, there was a very low understanding of the term, and meaning of, percentile.
- Nearly all participants considered themselves to understand the term, and meaning of, an average and felt comfortable interpreting this data.
- Bar charts were the preferred format for presenting numerical information. Line graphs were universally disliked across participants and there was some misunderstanding of the data presented through pie charts.

- Pictorial representations of data (i.e. images of different size houses) were favourably received and well understood.

- A simple textual statement to describe the numeric data, rather than any chart or image, was preferred by a few participants who were less comfortable interpreting data. However, overall participants did not feel that a textual statement is a suitable way to display benchmark information as it was less likely to attract the attention of the person reading the bill.

- Participants wanted data on energy usage to be displayed in terms of the amount of money spent (£s) rather than the amount of energy consumed (kWh). Comprehension of data was aided by interest in the data and so in relation to energy consumption data, participants were more likely to pay attention to data displaying financial expenditure.

- A calculator tool enabling participants to manipulate the data displayed to them based on personal factors was well received and worth exploring in relation to benchmark consumption data.

- Participants were interested in receiving additional information in combination with a benchmark to help them understand the possible steps to take as a result of the data.

The presentation options tested in the in-depth interviews displayed in section 2.4, took these findings into account by including: simple bar charts; pictorial alternatives to the bar charts; purely textual descriptions; an online tool; data based on expenditure; and additional information providing hints and tips on reducing energy usage. Designs presenting percentile data were also taken forward.

General reactions to the concept of benchmarking were also captured at the group stage. The reactions during the group discussions were more negative than those expressed during the in-depth interviews. In part this may reflect a group-effect as participants tended to reflect on their negative experiences and perceptions of energy suppliers and were less comfortable discussing their personal level of energy use, and ability to change this, than in a one-on-one setting. These discussions also did not test benchmarks that were based on participants' local area. It is likely that because relevant benchmark data was presented in the interviews, participants provided a more considered reaction to the concept. In the in-depth interviews, participants proved more willing to reflect on the energy usage of their household and its relative level compared to the usage of other households.

The analysis of the merits and shortfalls of different benchmark types has been informed not only by participant reactions captured through this research but also through the **statistical analysis** conducted. Ultimately, however the final benchmark recommendation has to balance statistical robustness, likely consumer appeal and the availability of the required data to energy suppliers. For instance, multivariate regression analysis illustrated the strong association between energy consumption levels and both the number of rooms and numbers of people in the household. This research suggested that, from a consumer perspective, the inclusion of these factors within a benchmark would increase its credibility and impact. However, it is unlikely that energy suppliers could access and use this data within their benchmarking and so the final recommendation takes all of these issues into account (as discussed in section 2.11).

2. Key findings

The following sections explore participants' energy consumption behaviour, their reactions to the concept and mechanics of an energy consumption benchmark, the preferred presentation formats and the possible impact of this information on their attitudes and behaviours. The findings of this research are intended to inform energy suppliers and policy makers when determining the content and presentation of benchmark information to consumers.

2.1 Understanding energy consumption behaviour

This research found that energy consumption can be an emotional issue for many participants. Energy was associated with having a warm and comfortable house, and in being able to provide for oneself and others in the household. In this context, participants said that they usually meet requests to reduce their energy consumption with a great amount of resistance. Few participants felt they had much control over the amount of energy they consume or how much they pay for it.

Most participants believed that they used the minimum amount of energy possible within their household given the lifestyles they lead and the type of property they inhabit. When reviewing energy use, participants tended to focus on changing suppliers or moving to a cheaper tariff, rather than reducing the amount of energy consumed by the household.

Budgeting for Energy Consumption

Across income groups and locations, most participants appeared to **set 'budgets' for the amount they pay for energy**. This is a key insight into consumption behaviour as participants did not focus on units of energy; rather, they viewed consumption in terms of the amount of money they spent. Much like other regular outgoings such as rent, or mobile phone bills, participants tended to ring-fence a certain amount for energy consumption, and reflected on how much energy they use only when the bills exceeded this set-aside amount.

> *"I already have a fair idea of how much we need to spend on gas and electricity. We've had such a cold winter, so it might be a bit more than usual. Maybe if it (energy bill) is far more than usual, I'll think about what I can do."*
>
> ***Female, Ipswich, PPM, Below average consumption,[4] Social Tenant***

Participants revealed that their budgets for energy consumption are typically determined by the income level of the household, rather than the kind of house they live in or the number of people in the house. A common sentiment, "I use as much energy as I can afford", illustrated the point that affordability influences the perception of energy required by the household.

Being Warm and Comfortable

Participants associated the levels of comfort and warmth in the house as being directly related to the energy consumption of the household. **Lowering levels of energy consumption is associated with discomfort** and most participants found this off-putting. Vulnerable participants, in particular, felt that they use the bare minimum level of energy and that to use any less would mean risking the health of household members.

[4] The energy consumption level (below average/average/above average), attributed to each respondent quoted within this report, is taken from the bill amount quoted within the interview and a comparison of this against the average annual gas cost for their specific area.

Participants associated reducing energy consumption with a lower quality of life, i.e. in relation to their use of energy for heating, participants did not think that it was possible to achieve the desired level of warmth and comfort by lowering energy usage. Consequently, few participants spontaneously mentioned efficiency as a means of lowering energy consumption. For many, the freedom to use as much energy as required came with the ability to pay for it.

> *"This is why I go to work, isn't it? So I can come home and be warm in my own house. What's the point of making money if I can't spend it on being comfortable?"*
>
> ***Male, Ipswich, Direct Debit, Above Average Consumption, Home Owner***

Some participants stated they could cut down energy usage and consider their current behaviour as 'wasteful', but felt that the effort taken to cut down energy usage may not be 'worth' the financial savings that might be made.

Controlling Energy Consumption

Most participants believed that they **have little or no control over how much energy they need or use**. For many their level of energy consumption was dictated by the age of the house, or because they live in a particular area of the city/ region. Participants assumed that energy efficient appliances require significant investment or are in a higher price bracket compared to lower-rated appliances.

When considering both gas and electricity consumption, participants felt they have less control over the former, as gas tends to be used for cooking and heating, which they felt cannot be significantly changed.

Children's behaviour and lack of energy cost awareness was frequently cited by many participants as one of the reasons for being unable to control energy consumption in the household. Participants felt that children tend to leave lights and appliances on, and that their children's behaviour could not be easily changed.

Change in Circumstances

Participants appeared to **reflect most on their energy consumption levels when faced with a change in personal circumstances**. For instance, those who had recently retired had to consider the fact they are likely to spend longer hours in the house, and may have to rework their energy budget. Similarly, it was clear from the research that participants who had recently had children were more likely to think about changing energy consumption levels.

2.2 Attitudes to billing

During the process of the research, participants were asked to share their spontaneous views on energy bills to understand their perceptions of energy bills; what kind of information they find useful and what, in an ideal situation, they would like to see on their bill. This section covers participants' views on the content of bills: how they use bills, and their reactions to them.

2.2.1 Spontaneous views on bills

Energy bills were often discussed at first in an 'abstract' sense. The 'bill' was not associated by all participants with the actual document. Instead it was often thought of as a single figure; the amount owed, or whether the householder was in credit or debit with payments. The majority of participants stated that they look no further than the very first page of their bill.

> *"I look at either to see how much we've overpaid or underpaid."*
>
> ***Female, Tandridge. Payment on demand. Above Average Consumption. Homeowner***

> *"I would look to see if my direct debit was covering it and that would be it."*
>
> ***Female, East Renfrewshire, Direct Debit, Below Average Consumption, Homeowner***

> *"But what I really read is the front page. I don't even read the back page, which tells me, either we will carry forward a balance, you owe us, or we carry forward a balance that they owe us. So I actually only read the front page."*
>
> ***Female, Tandridge. Payment on demand. Above Average Consumption. Homeowner***

Many participants kept their energy bills to retain a financial record, as a reference document to allow a historical comparison with older records or as proof of address and identity.

The research found that in most households, the responsibility for dealing with energy bills lies with one person. Most participants perceived bills as 'deliberately' confusing and some treated much of the information they receive through their bill with suspicion.

> *"What does that mean? It doesn't mean anything at all. It's just numbers."*
>
> ***Female, Eltham, Direct Debit, Above Average Consumption. Homeowner***

The calculations on the bill (the calorific value calculation[5] or initial and main electricity unit rates) were seen as obscure and complex by most participants. Many felt suspicious about the small print on price calculations, as they thought this is used by suppliers in a deliberate attempt to hide costs.

Participants looked for information on their bill to see if the amount stated was based on an estimate or an accurate meter reading, with a strong preference for the latter. A few looked at the data on kWh they have used, even if they said that they do not understand what a kWh is. Some looked at this data because they find it interesting to see how much energy they have used, while others used it as a benchmark against their historical records, to be able to compare bill increases with similar periods, i.e. have they actually consumed more, and hence have to pay more, or was the payable amount increase due to a rise in the price of energy.

> *"I like to compare what we used in that period the year before, like in consumption. I do like usage comparison and tables which they do give you."*
>
> ***Female, Eltham, Direct Debit, Above Average Consumption. Homeowner***

[5] Calorific value (CV) is a measure of heating power and is dependent upon the composition of the gas. The CV refers to the amount of energy released when a known volume of gas is completely combusted under specified conditions. CV information is provided daily to gas shippers and suppliers, which is then used to bill gas consumers.

2.2.2 Levels of engagement with energy bills

The research showed that attitudes towards energy bills varied somewhat by the three principal payment methods: PPM (Pre Payment Meter), Monthly Direct Debit or Payment on demand (usually quarterly payments on receipt of bill).

- **PPM customers** involved in this research had the lowest interest in, or engagement with their annual statement, as their focus was on week-to-week use and expenditure. They were very energy conscious, especially as an increase in energy consumption was immediately translated to higher or more frequent top up payments.

- **Direct Debit customers** involved in this research had low interest in, and engagement with the bill since their focus was on the monthly payment amount. However, the level of direct engagement depended on the person who was in control of the bills, their lifestyle and other factors.

- **Payment on demand customers** involved in this research appeared to have the highest level of interest in their bills. As their actual payable amount varies quarterly, they tended to pay more attention to details. Some participants made a conscious choice when opting for payment on demand rather than direct debit as they felt it helped them exercise greater control over energy costs.

For participants who received a paperless bill online, this research found no notable variation in their level of engagement. Instead, there were some online participants who said they checked the amount they owed, while others did not engage with their bills at all. Some of these participants suggested they would engage further if they had a hard copy through the post.

2.3 Attitudes to energy consumption benchmarks

Participants were introduced to the idea of energy consumption benchmarks through stimulus materials. This helped gain insight into how they perceived benchmarks, how they might use such information and how it might impact their behaviour. Two key types of benchmark were tested: 1) A comparison against the **average bill** in their area and 2) A comparison against the **highest and lowest bills** in their area (based on percentile data).

2.3.1 Concept of benchmarks

The concept of a benchmark was welcomed by most participants. A few participants said they were already used to receiving comparison data on their household's previous consumption through their bills. Some participants felt a benchmark displayed on their bill could be a starting point for increasing awareness of their usage and how this compared to others.

> *"Well that's incredibly useful, because it allows a comparison. It's a comparison that you need to make. Are we... are there any ways we can become more efficient in terms of expenditure and global impact I guess. I mean that is a secondary consideration. So yeah, it allows some comparison."*
>
> ***Male, Tandridge, Payment on demand. Above Average Consumption. Homeowner***

"They tell me how much I used last year to compare how much I used this year. … And yes, I think it is helpful because the last time they done that it went up from the previous year and then I started thinking, well how am I using more energy if I'm doing exactly the same?."

Female, Eltham. Direct Debit, Above Average Consumption. Homeowner

A minority of participants said they would not like to receive a benchmark on their bill; however they were not hostile to the concept of a benchmark itself. Instead, they preferred this type of information to be available to consumers who actively sought it.

A few participants with very low energy consumption behaviours suggested **positive feedback** about their low level of consumption would be preferable to receiving benchmark data. These participants felt that positive feedback would make them feel their efforts of consuming energy only as necessary were valued.

Despite welcoming the information on their bills, very few participants spontaneously said that they would find the benchmark motivating enough to change their energy consumption behaviour. This was true even of participants who were shown to be consuming above average for their area. Instead, participants tended to see this information as a tool that could play an important role in helping determine if they were on the best supplier deal or tariff possible.

Initially, some participants tended to be defensive and felt that **reducing energy costs would involve a large amount of investment** in superior technology or better appliances, while others believe they would have to reduce heating in the house. However, during the course of the interviews, many participants **reflected on their energy consumption behaviour**, pointing out instances where they could change the way they consume energy and reduce bills.

This research found that in order for the information to be perceived as credible it needed to be endorsed or approved by an official organisation, a government agency or an independent body in the energy industry.

"You don't trust energy companies. It would have to be backed by a government department statement. I mean there's nothing to stop it going on the bill is it, but it would have to be officially endorsed. It's an inherent contradiction isn't it, because energy companies are only interested in selling you energy."

Male, Tandridge. Payment on demand. Above Average Consumption. Homeowner

2.3.2 The concept of 'average'

The term 'average' appeared to elicit a wide range of responses. For a few participants the term 'average' was immediately considered meaningless leading them to dismiss the data outright. However, a fair proportion of participants were willing to make their own judgement about what the average data might mean and how relevant it was to them. It is difficult to report a general reaction to the term 'average' across participants due to this range of reactions and because, over the course of a discussion about average usage data, individual participants tended to change their own opinions.

Some participants suggested that **defining the term 'average' would be helpful and increase the credibility of the information**. For instance, this research showed that an explanation such as "the average is considered to be a 3 bedroom house with 2 people", might help to overcome initial confusion about the term. Even when participants were given the explanation of the figure as a mathematical average of the energy bills in their area, they said they wanted to know the characteristics of the 'average' house.

"Because the word 'average' doesn't mean anything. To me, you know, if you're talking about the borough of Greenwich, how would you pick an average home? It's complete and absolutely useless information because you're not an average; no-one's an average, it's individual. I would consider this a very normal type home but depending whether you're comparing it with very large houses sort of going to Eltham towards the high street, or an apartment over the road, you know, what their bill is as an average all put together how would that be of any use to me? It wouldn't."

Female, Eltham. Direct Debit, Above Average Consumption. Homeowner.

"An average is kind of meaningless as each house is different. Each home uses varying degrees of energy depending on its size, insulation, type of heating and all that. An average doesn't mean anything really unless you all stay in the same type of house."

Female, East Renfrewshire, Direct Debit, Average Consumption,Homeowner

Many participants felt that the concept of 'average' did not apply to them. Even in relatively homogenous areas, participants felt that the circumstances of each household were extremely different, and therefore the average figure lacked credibility. This research found that the **idea of an average was challenged on two grounds – physical characteristics of the house, and circumstances of the household**. Participants considered physical characteristics to include the age of the house, how well insulated the house is, whether it is a detached or terraced building and so on. Participants considered circumstances of the household to include lifestyle, household composition, the working hours of members of the household and so on. However, it was clear from the various stages of this research[6] that these barriers to engaging with 'average' data were less likely to be raised once participants were presented with actual, and relevant, benchmark figures.

Participants were unlikely to make a distinction between different forms of average (mean, median or mode). From a statistical perspective the **recommendation is to use median data** as a greater proportion of consumers will be shown to be consuming above the median, than the mean. Based on this research, this presents greater opportunity for behaviour change. Further details on the findings from the statistical analysis which have informed this recommendation are included in section 2.11.

This research found that participants dismiss a benchmark based on a national average, or based on an average usage for the same type of property regardless of geographic location. They felt that there were too many varying micro climates in the country for this comparison to be valid. Participants wanted the **average to be based on localised data to make it more meaningful**.

There was significant variation in how participants **interpreted the term 'local'**. For some it meant an area as small as their estate or street and for others it meant their village, local authority area or even county. However, only a few participants thought there would be a real benefit in including the definition of 'local' (i.e. as the surrounding 500 properties) alongside the benchmark as most felt this term was better left for their own interpretation. Participants tended to feel that further explanation of the term 'local' could make the presentation more, rather than less, confusing.

As noted previously, some participants immediately associated the benchmark with a source of information that could help determine whether they were on the best possible tariff. Consequently, some participants felt that **information based on a particular provider and tariff** was necessary to emphasise the idea of comparing energy consumption.

[6] Participants in a group situation are far less positive about energy consumption benchmarks than when they are engaged one-on-one using accurate benchmark data calculated for their area. The initial group discussions did not present participants with benchmark data but only considered the concept of receiving this information.

2.4 Presenting benchmark data

Participants were shown different ways of presenting an energy consumption benchmark. Some of these presentations were in simple text format, while others were charts.

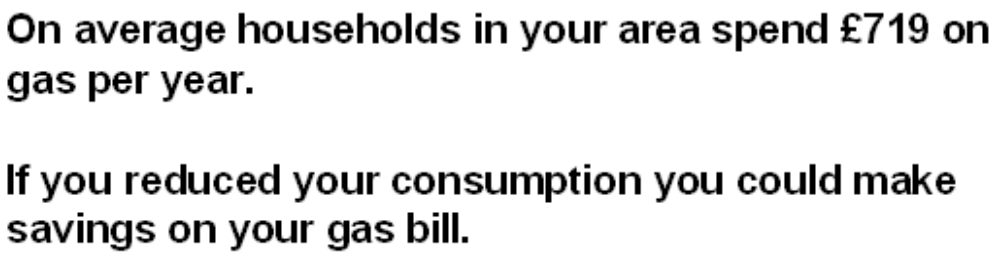
2.4.1 Reaction to different presentations

Text displays

Participants were shown text-based mock-ups describing the benchmark. They were shown descriptions of both the average bill amount (e.g. Figure 2) and the average consumption value. The benchmark figure varied depending on the location of the participant.

Participants found find this text-based presentation acceptable and easy to understand. However, their preference was to use graphics in order to make the information more eye-catching. Participants felt that a text statement was unlikely to be read, and would not be noticed, unless used in conjunction with a chart. A very small minority preferred a text-based presentation like this on their bill.

Fig 2: Text based presentation



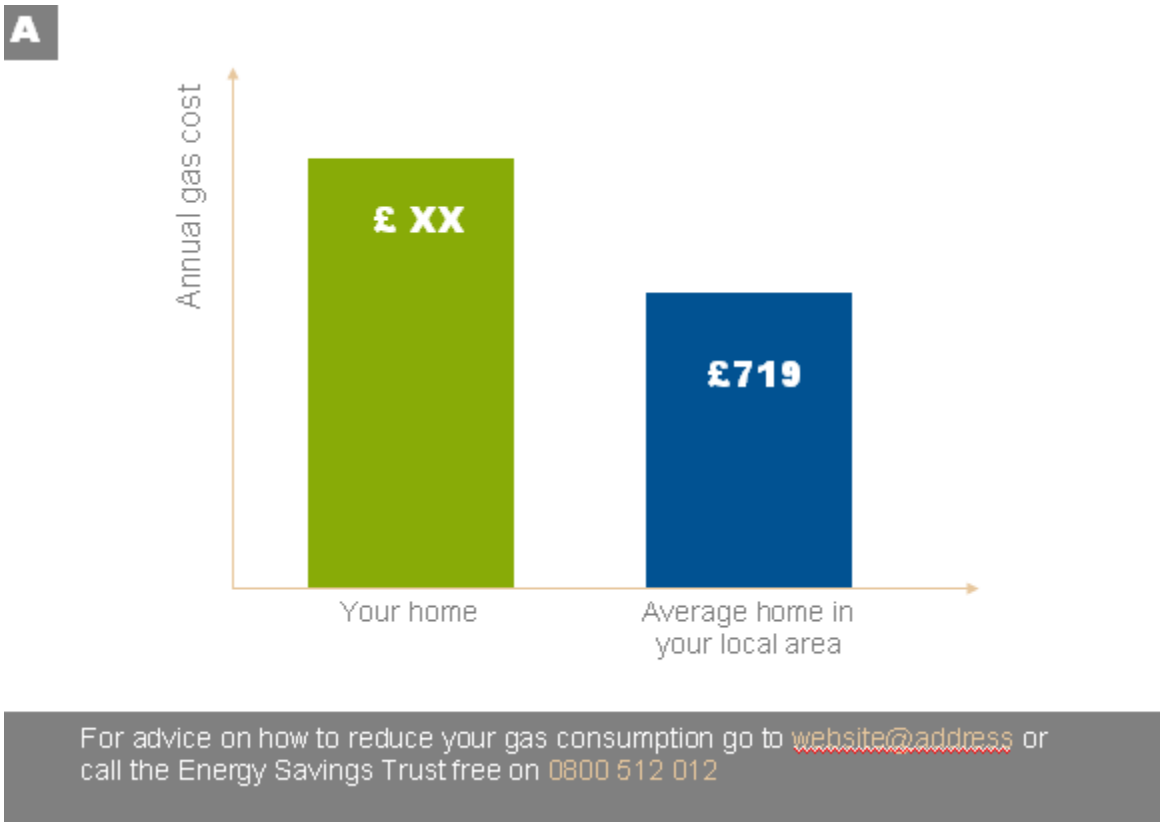
Charts

Participants were shown a variety of charts during the course of this research. This research found that the use of visual representations of the data, rather than a text-only statement, tended to increase participants' levels of interest in seeing benchmark data on their bill.

Participants stated that they understood a simple comparison of their home against the average in their local neighbourhood (e.g. Figure 3 overleaf). A similar presentation showing the number of kWh hours consumed was also shown, but participants felt that seeing the monetary amount (i.e. with the symbol £) spent had greater impact than kWh. This reflected low levels of understanding and familiarity with the term kWh.

> *"Anybody identifies all sorts of things with money. Energy units are not part of day to day conversations."*
>
> ***Male, East Northamptonshire, Direct Debit, Below Average Consumption, Homeowner***

Fig 3: Graph-based presentation



Participants found the charts represented by coins (see Figure 4 overleaf) eye-catching, as it encouraged them to make an immediate connection with money. This research found that the use of such imagery tended to have a bigger visual impact and therefore increased the attention paid to the information by participants.

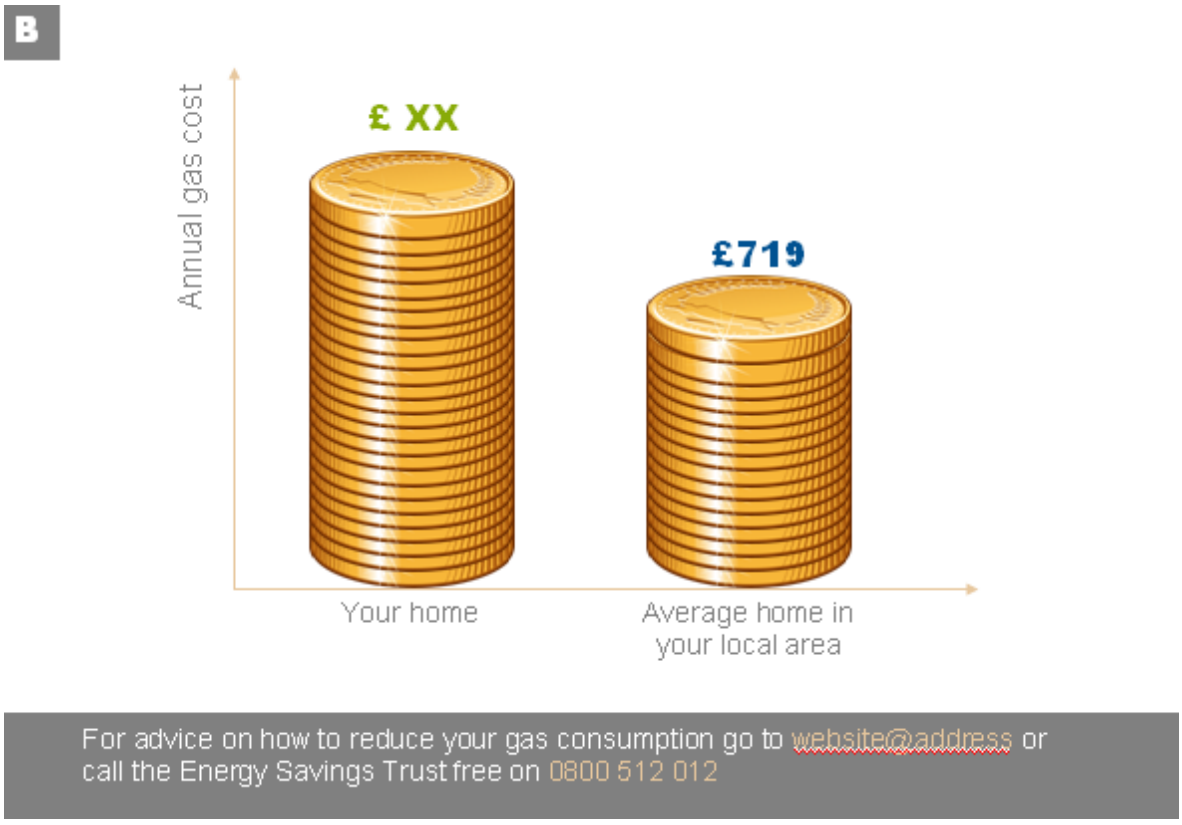
> *"We all like looking at money and handling money, and so coins would be better than just bars."*
>
> ***Female, Eltham, Direct Debit, Above Average Consumption, Homeowner***

However, not all participants agreed that the use of images added to the presentation and its impact and preferred more straightforward block bars.

> *"The clearer you make it, the less confusing it will be. People see boxes on an every day basis like on TV all day, like with investment shares, or even voting results on shows like X-Factor, they will get it. It is easy to understand, with the coins it confuses the brain, what am I looking at?"*
>
> ***Male, East Northamptonshire, Direct Debit, Below Average Consumption, Homewoner***

While generally participants preferred a format that focuses on money, some felt that a format combining money and usage (i.e. including both £ and kWh) might increase awareness of the direct association between the amount spent and the kWh's consumed. For these participants there was a feeling that presenting both units of data could help them to engage more with units of energy. If this option is not feasible, this research suggested that the format presenting the amount (in £) alone is preferable to participants than the format with only kWh consumption.

Fig 4: Graph-based presentation (Coins)



Participants were also shown benchmarks based on a range of percentile data (see Figure 5 overleaf). These were based on the top and bottom 10% of meter-point usage values for the area, and also the top and bottom 20%. While some participants preferred this presentation over the average data, the rationale for their preference raised two causes for concern.

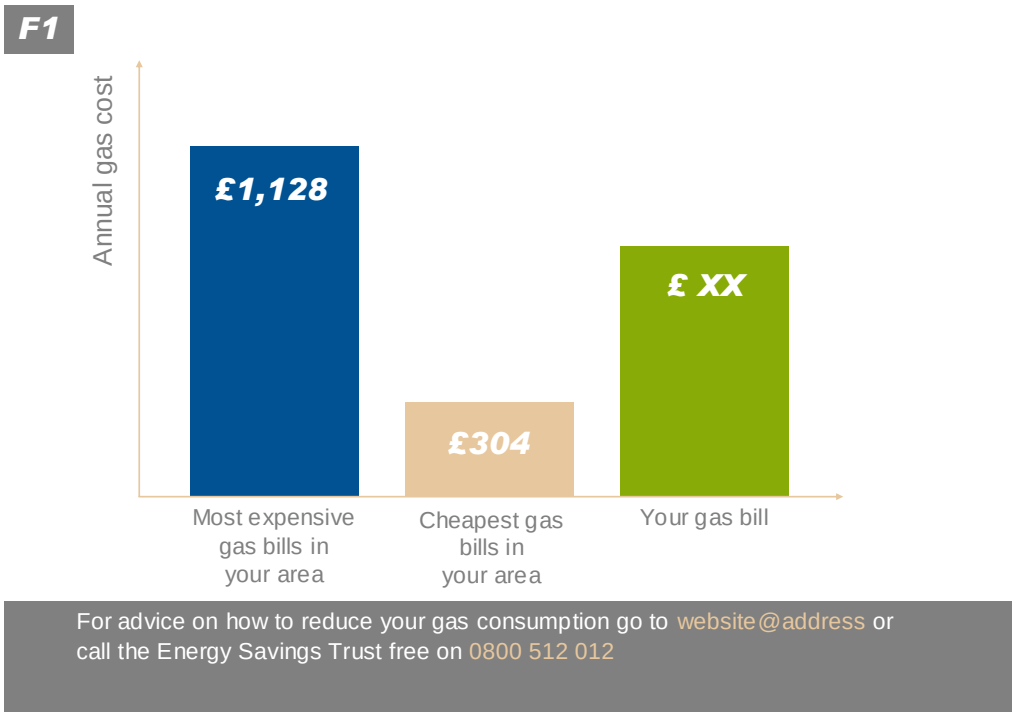
First, participants who preferred the percentile presentations tended to describe their consumption level as falling between the lowest and highest energy users whereas when looking at the average presentation option they described their energy usage as high compared to that of others. In other words, the percentiles encouraged them to consider their level of consumption as acceptable, and so less likely to take action to reduce it. This contrasted with the ultimate aim of the benchmarks to reduce energy consumption, where appropriate.

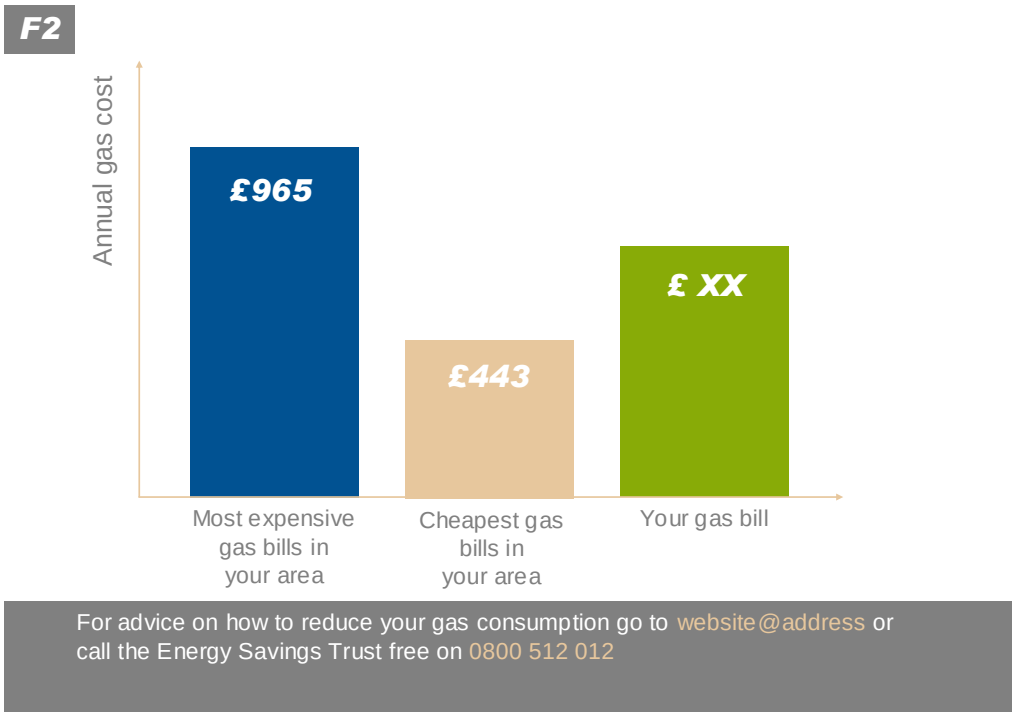
Secondly, participants often misinterpreted the message being communicated by the data. Many participants interpreted the percentile data as an indication of the range of tariffs available in their area. The research suggested that for these participants the primary impact of the data would be to encourage them to look for an alternative supplier or tariff. In very few cases was this data linked by participants to varying levels of usage across different households and so it would be very unlikely to encourage a change in consumption levels.

Where a connection *was* made between the percentile data and usage, rather than price, of energy, participants largely reacted negatively to these presentations because they assume the top values are for the largest households in the area whilst the lowest values were for the smallest households. This meant participants felt the data was of little value to them and could only be made meaningful by ensuring the highest and lowest values were all from very similar property types, household compositions and circumstances.

This research shows that the risks of misunderstanding and misinterpretation among participants were reduced when using a simple average comparison, hence the recommendation to use average data as the basis for a benchmark.

Fig 5: Percentile-based benchmark





2.5 Additional information to accompany benchmark data

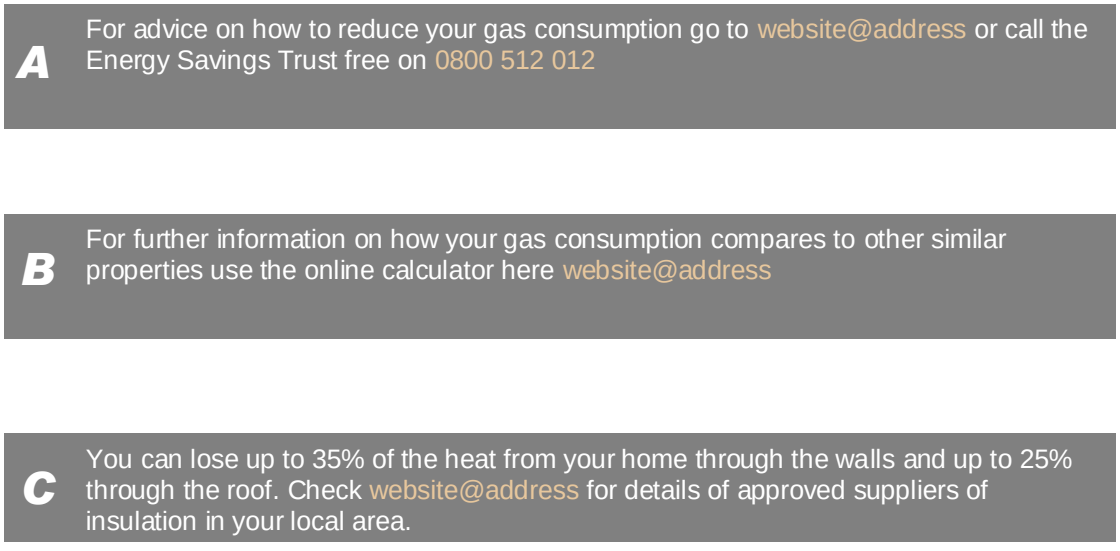
Participants believed **additional information presented below the benchmark would be a useful feature** to have included on their bills. They were presented with three options (see Figure 6 below). The majority of the participants preferred statements A and B, whereas statement C was deemed inappropriate by some as they had already installed insulation. Participants appeared to be confident about using web sites or free phone numbers as a starting point of their own research on how to reduce their gas and energy consumption.

Participants stressed that the information needed to vary over time, introducing new ways to reduce energy consumption. Participants felt this could include:

- Links to web sites and online tools, where participants could get further information on how to reduce their energy consumption, find approved companies for insulation, etc.
- Hints and tips on reducing energy consumption, including explicit mention of the amount of money likely to be saved as a result of these changes.
- Average costs of common appliances expressed in £ per kWh. Participants felt this information could help them engage with energy units.
- Some eco-conscious participants said they would welcome information about further CO2 savings and the environmental impacts associated with consuming less energy.

For the additional information to be interesting and have maximum impact, participants thought it should be **included below the benchmark** in a bold colour, or as dark coloured text on a lighter background. In the stimulus given, many participants overlooked the statement as the background colour of the text (grey) was not eye-catching enough.

Fig 6: Additional information



This research also tested whether consumer bills should include information about how the benchmark had been calculated and the data it was based on. While participants liked the idea of having some form of benchmark data that was relevant to them, they were not interested in receiving a detailed explanation of it on the bill. While many participants had negative perceptions of energy suppliers, they appeared to trust the information presented to them on their bills as they considered it to a piece of 'official communication'. Participants suggested that this level of trust could be increased further through an endorsement of the benchmark by government or a watchdog, such as Ofgem.

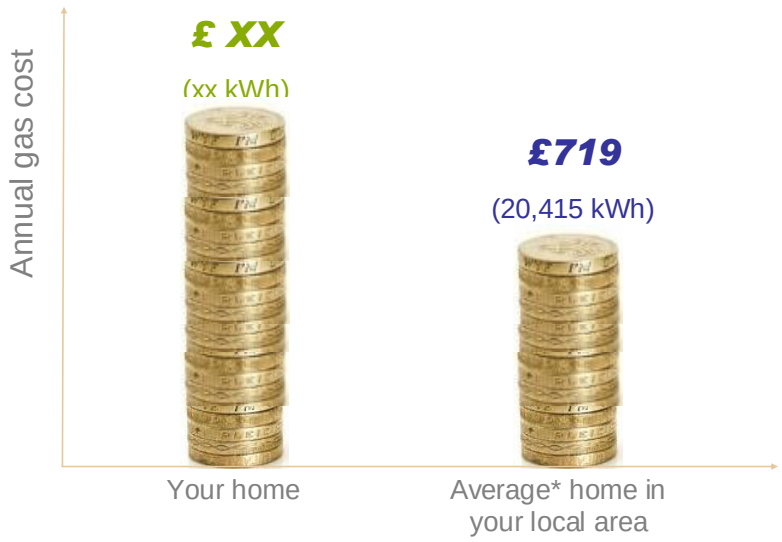
2.6 The 'preferred' bill

Participants were asked what information should preferably be displayed on their bills. Many stated that they wanted price comparisons on their bill, either by different tariffs available, or based on different suppliers. They did not spontaneously ask for comparisons with other households, however, when prompted with the concept, they were typically open to its inclusion in the bill.

Participants liked the idea of receiving historical trends for their own energy usage on their bills. This was raised spontaneously by some and others were aware that it was already provided by some suppliers. Participants also said that hints on saving energy, especially in relation to how much money could be saved, were welcome but needed to be varied across bills so they were given new information over time.

Participants found the inclusion of kWh confusing and were unable to relate to the term as they did not know how many kWh they consumed when they ran the tumble dryer or used the kettle. A few mentioned that communicating kWh as energy units might be simpler, along with an explanation of how much money it costs to run common household appliances. Figure 7 illustrates how the energy consumption benchmark might preferably look given the reactions and feedback.

Fig 7: Preferred presentation of benchmark data



* An average home in your local area is considered to be a 4 bedroom house with 5 occupants

Save £50 per year by turning your thermostat down by 1ºC rather than opening windows.

For advice on how to reduce your gas consumption go to **website@address** or call the **Energy Savings Trust** free on **0800 512 012**

2.7 Online calculator tool

Participants were shown a mock-up version of an online tool which they could use themselves to compare their energy consumption with other households. For some an online comparison such as this was interesting, uncontroversial and familiar. Many participants welcomed the idea of such a tool as it would allow them to compare themselves against the local average based on self-selected criteria which would provide them with greater confidence in the validity and relevance of the benchmark.

Participants believed the tool's functionality increased with the number of the options it includes. They wanted the tool to enable a comparison based on:

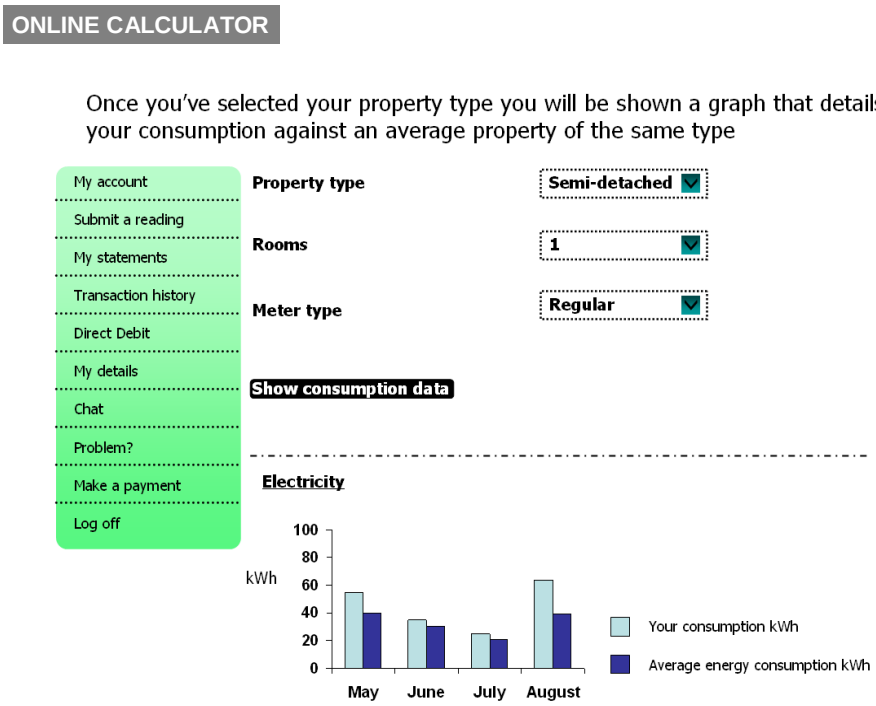
- Number of people in household,
- Age of people in household,
- Age of property,
- Location – by county, local town or postcode.

Participants also suggested that including details of insulation or appliances within the tool would improve the accuracy of the comparison even further. The ability for consumers to generate a benchmark specific to their own property and household characteristics was considered a powerful way to encourage behavioural change by participants.

Participants acknowledged that using an online calculator tool required them to take a pro-active approach. They felt they were most likely to consult such a tool when they were reviewing their finances or the cost of their energy usage. The research found that those who were relatively engaged with their bill were more likely to use the tool, although having a wide range of options could help in reaching out to those who may not be as engaged.

The example online comparison tool shown to participants is included below as Figure 8.

Fig 8: Online calculator tool



2.8 Setting targets for household energy use

The literature review conducted to inform the research suggested that consumers outside the UK reacted favourably to, and were encouraged to change their behaviour by, target-setting within bills.

However, this research found participants were very negative towards the concept of target-setting. Participants said they would not accept a target level of energy consumption set by their supplier based on the average usage of other households. The concerns that many had about the applicability of an average usage figure, due to differences in property type and personal circumstance, were large barriers to engagement with targets.

A few participants did think it was appealing to set their own energy consumption targets and track their progress however. The participants interested in this were those who tended to look at their bills more closely which appeared to be older participants and also those who paid on demand (often on a quarterly basis on receipt of a bill).

The statistical analysis conducted as part of this research showed that it is possible for consumption targets, based on expected levels of usage, to be calculated at a wider geographical scale. This would allow areas to be identified as either over or under-consuming based on the expected level of consumption for that area (e.g. as characterised by particular household and property types). Neighbourhood Statistics (NESS) and Scottish Executive residential data were used to conduct a regression-based technique to identity the characteristics of an area which have a significant relationship with energy consumption. The most significant factors influencing consumption across an area were found to be:

- Average household size (based on number of inhabitants)
- Average number of rooms per household
- Proportion of households owned outright
- Proportion of semi-detached dwellings
- Health deprivation and disability score (taken from the Indices of Multiple Deprivation)

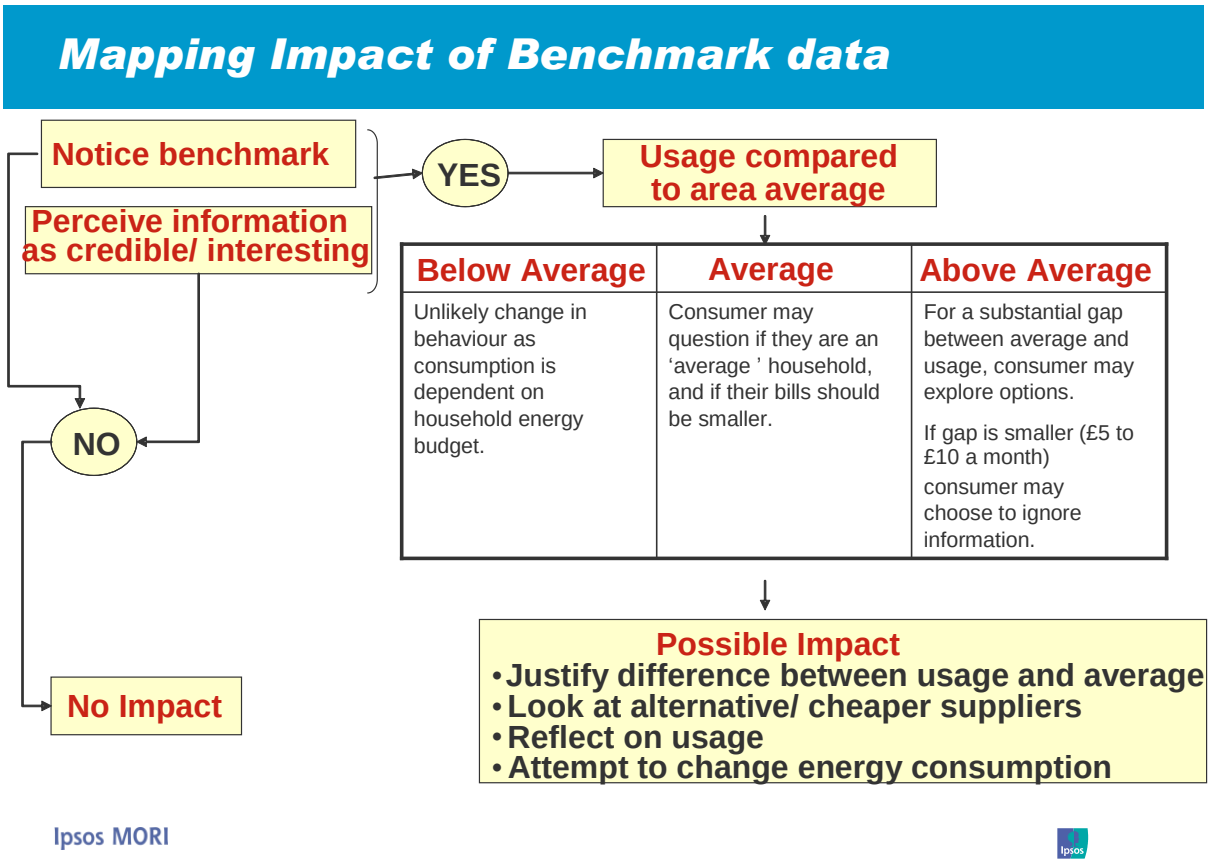
One of the outputs of this research is a dataset showing which Lower Layer Super Output Areas (LLSOAs) in England and Wales, and Intermediate Geography Zones (IGZs) in Scotland, have been identified as either over or under-consuming gas and electricity based on an expected level according to the factors listed above.

Further detail on the regression technique used and the final model specifications is included in Appendix D.

2.9 Impact of benchmark data

The reactions of participants captured through this research suggested that the impact of an energy consumption benchmark was dependent on a number of factors including the visibility of the information within the bill, its perceived credibility and how the household's usage compares against the benchmark. Figure 9 overleaf sets out the process that participants went through as they responded to the benchmark mock-ups, as observed during the research.

Figure 9: Mapping the likely impact of benchmark data



The key factors affecting the likely impact of the benchmark data on participants are discussed below.

Noticing benchmark information

In the first instance, participants said **the impact of the benchmark would depend largely on them noticing the information**. When participants received their energy bills, they said they focused on how much they had paid or needed to pay, and ignored other parts of the bill. To ensure impact, participants' stressed the placement of the benchmark needs to be prominent in the bill, preferably just under or next to the bill amount. Participants thought the presentation of the information itself needed to be in a bold colour although they did not like the use of the colour red given the negative connotations it portrays.

> *"Front page where the empty space is, because it hits when you see the price. I don't read the other pages."*
>
> ***Female, North Wiltshire, Payment on demand, Below Average Consumption, Social Tenant***

Participants thought it was essential that the benchmark was included within the bill. They said they only considered their own energy consumption when they received their bill and so this was the optimum time to attract their attention to information about how their consumption compared to others. While a few participants thought having this information presented separately would be useful (on the basis that it could then be a document that can be shown to others and discussed), most acknowledged that it might not get as much attention than if the benchmark is presented adjacent to the bill amount. Participants stated a preference for being shown annual comparison figures. They felt annual figures were likely to have a greater impact than monthly figures since they were more helpful in assessing how much they could save over a year.

Credibility of benchmark information

Participants did not question the credibility of the benchmark, and felt they would accept its validity if it appeared within their bill which they considered as official communication from energy suppliers. The **credibility of the information is enhanced by explaining the term 'average'** by providing the type and size of the property, rather than by providing the mathematical techniques applied to calculate the figure. There was also a suggestion from some participants that endorsement of the benchmark from an official source such as the government or a watchdog, such as Ofgem, would provide greater credibility.

Comparing a household's usage against the benchmark

Participants were asked to compare their actual bills against the calculated benchmark for their area. They **tended to react in different ways depending on their circumstances and the amount of difference between their usage and the benchmark**. Participants who felt the difference between their bill and the benchmark was relatively small, said they would be unlikely to act on the information. On the other hand, those felt that their bill was far higher than the benchmark for their area said they would be likely to start looking at alternate suppliers to see if their bills could be lowered. Whilst this intention was driven by financial motives, some participants felt that this greater engagement with their bill could lead to behaviour change, in particular if they did not see a reduction in their bill after switching.

Participants, who used less energy than the average household in their area, said they would be unlikely to use more energy because of the benchmark. This was because these participants were either using as much energy as their budgets permitted and could not afford to increase their usage, or in a minority of cases, because they had already taken substantial steps to reduce their consumption (such as installing solar panels) and were aiming to achieve low usage regardless of the consumption levels of other households. However, while the views of low-consuming households captured through these interviews were universal on this front, it is worth bearing in mind that only 10 of these participants were engaged through this research. Other studies[7] have shown that low-consuming households may indeed increase their energy use after receiving benchmark information. Understanding the precise response among this group would require further longer term research such as a trial. The attitudes collected through this research for low-consuming participants are explored in more detail in section 2.10.

Participants whose bill appeared to be similar to the average in their area said they might choose to ignore the benchmark, even if in actuality their usage should be lower given the number of members in the household or other aspects of their household circumstances.

Bill as a proportion of household income

Household income was a significant driver of energy consumption as participants tended to consume as much energy as they could within their financial energy budget. For households where the energy budget was a smaller portion of their overall income, saving money on their bills was seldom a priority. The benchmark alone, according to these participants, might not be enough to help them reflect on their energy consumption. On the other hand, households with a smaller income said they were likely to engage with any information they thought would help them save money.

Participants whose bill was above the average for their area were likely to engage with the benchmark to help them understand why they were consuming more than others, and how they could save money. However, if their energy budget is a small part of their income, saving money may not be motivation enough. Participants from households on a relatively low income feel that this information could be a catalyst to lead them to explore alternative tariffs or in a few instances change their behaviour.

[7] See appendix D: Review of existing literature

Additional factors influencing impact of benchmark

In addition to the factors listed above, this research suggested that the profile of the participant themselves can make a difference to how likely they were to think this information could lead to a change in their behaviour.

- **Financial behaviour**: Participants who viewed themselves as careful planners of personal finances are likely to be more engaged with their energy bills. This research found that they tend to value any information that could help them save money or manage their finances, and therefore may act on the benchmark. It should be noted that these participants were likely to have already looked for information regarding alternate suppliers, and will need practical information on cutting down energy usage.

- **Home ownership**: Participants who were homeowners appeared to feel that they had more control over energy usage as they could make changes to their home, e.g. install loft insulation or double glazing, buy a new boiler etc. Participants who were renters, in either social or private housing, seemed to find it easier to justify higher than average energy costs. These participants tended to focus on the features of the house rather than reflecting on their own behaviour.

- **Role in the household**: This research found that within most households, the individual with primary responsibilities for household finances would be most likely to engage with the bill. Whilst typically keen to save money on their energy bills, these participants could be initially defensive when presented with information that suggested that their bills might be higher than average. This was possibly because they felt that they had not managed to secure the best possible deal for the household. They were however more likely to be receptive to the idea that energy bills could be reduced by changes in household behaviour as it spread the responsibility for the energy bill to other members of the household.

- **Household priorities**: Some participants felt that saving money on energy bills was a time intensive task, and that the amount of time spent may not be justified by the possible cost savings. This was particularly true for participants who felt they were well within their energy budget, and that saving money on energy was not a pressing need.

- **Moments of change**: Participants who had gone through a period of change in their lives such as retirement, bereavement, moving to a new house, having children etc. tended to reflect on how much energy they used and the financial implications of this. These participants welcomed a benchmark as it would help them make decisions about home improvements or changing suppliers/ tariffs.

- **Environment consciousness**: Very few participants said they changed or would change their energy behaviour because of environmental concerns. This research suggests that participants were more likely to be motivated by being able to save money rather than the idea of being environmentally conscious.

2.10 Attitudes of low income pre-payment meter participants

The attitudes presented in this section refer to those participants involved in this research that were classified as socio-economic grade of D or E and who were PPM participants. These were the participants who tended to use less energy than average for households in their area. The views expressed by these participants were also matched by those of other vulnerable householders, such as elderly homeowners.

Some of these participants found it difficult to heat their homes. They tended to opt for fewer hours of heating, or lower temperatures in their homes. Their attitudes to the concept of a benchmark for energy consumption tended to be similar to other participants. They found this information useful and were interested in seeing how their consumption compared to that of other households in their local area. Also in line with the overall findings, these participants were most likely to use the benchmark as an indicator that they could secure a better tariff or supplier rather than to reflect on their relative level of usage.

This research did not find any evidence to suggest that low income PPM respondents who were consuming lower than average levels of gas on an annual basis would increase their consumption as a result of receiving this information. These participants felt that their financial constraints forced them to use less energy, and as such were unlikely to increase consumption as long as these financial constraints existed. The provision of a benchmark would be highly unlikely to have a negative rebound effect on the energy usage of these participants as they had a high awareness of how little fuel they use and how it doesn't meet their needs. These participants stressed that their level of consumption was dependent on their overall financial circumstances rather than the desire to consume less energy.

While the views of low-consuming households captured through these interviews were universal on this front, it is worth bearing in mind that only 10 of these participants were engaged through this research. Indeed, for a robust conclusion on the impact of an energy consumption benchmark for any type of consumer, whether above or below the benchmark, a trial would need to be conducted to test the real impact of the information provided on their actual usage over a period of time. This research is limited by the fact it asked participants hypothetically how they might respond to benchmarks rather then being able to review how they have in fact. This would require a live trial.

3. Selecting appropriate benchmarks

The following section explores the most appropriate benchmarks to include within consumer bills based on the findings of this research. It presents the advantages and disadvantages of the various benchmarks which could be used based on both participants' reactions and from a statistical perspective.

The participant reactions captured through this research point to **a form of central tendency as the most appropriate benchmark** to present on energy bills.

This provides three statistical options; arithmetic mean, median or mode. Previous Lower Layer Super Output Area (LLSOA) level energy consumption statistics published by the Office of National Statistics used the mean. However, analysis of the meter point level gas and electricity datasets, provided by the Department of Energy and Climate Change for this research, was conducted to determine the most appropriate form of central tendency to put forward as a recommendation for a benchmark within consumer bills. The results of this analysis, when considered in conjunction with tested consumer reactions, pointed to the merits of using a median. The reasons for this decision are set out below.

Firstly, the mode will not be a useful form of central tendency to use for benchmarks on the basis that the mode gives the most frequent value and in this case, very few meter points had exactly the same value.

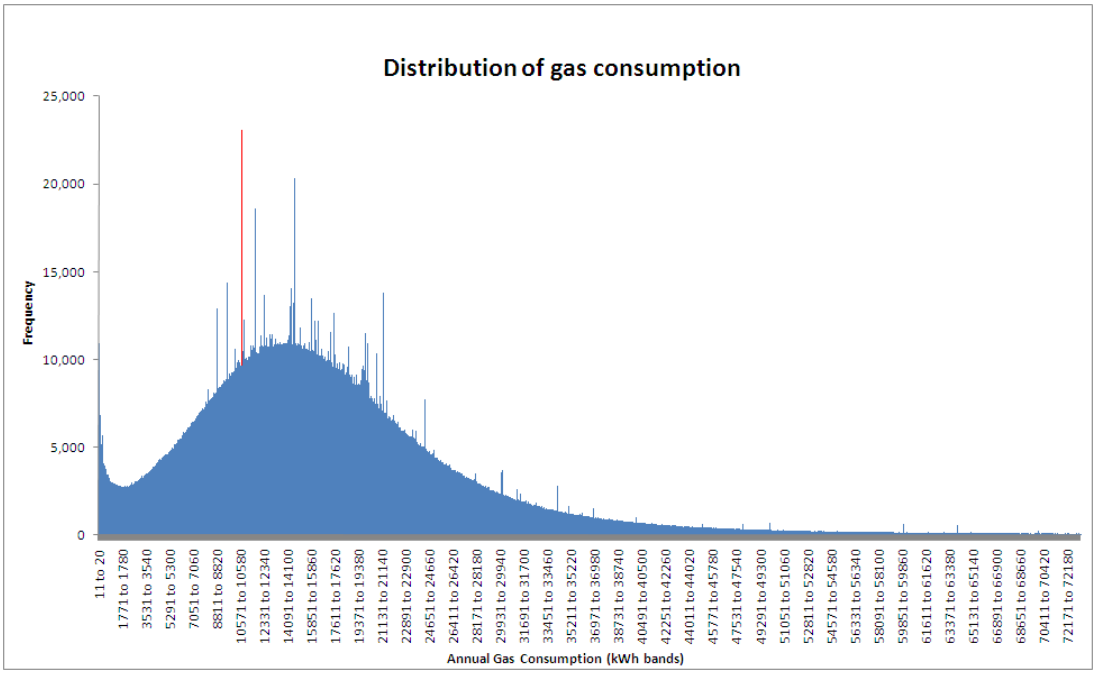
The median is an appropriate measure as it was more robust to a small number of very large outliers in the datasets than the mean and mode. A further argument for using a median as the benchmark is based on the proportion of participants who would be shown to be above and below this value. The qualitative research showed that participants' current level of energy consumption impacted on their receptiveness and likely behavioural reaction to benchmark data, with those high above the benchmark figure the most likely to think about the reasons behind their usage. It would therefore be advantageous to select a benchmark which shows as many consumers as possible to be above average. The analysis of the meter point level gas and electricity data sets showed there was a positive skew in the consumption data, particularly the electricity data, which resulted in the mean value almost always being above the median value. This meant fewer participants would be shown to be above the mean than the median value and, therefore, benchmarks based on median values would be most appropriate.

Figure 10 below shows the percentage of LLSOAs/IGZs where the value for the mean was higher than the values for the median (50th percentile). In a large number of LLSOAs/IGZs the mean was even higher than the 60th percentile, particularly for electricity consumption. This was expected given the greater positive skew in the electricity consumption distributions. This is illustrated clearly in Figure 11 below, which shows the distribution of profile 1 electricity consumption for one English LLSOA. The mean for this LLSOA is over 3,000 kWh, which is higher than the 60th percentile (2,643 kWh).

Figure 10 – Percentage of areas where the median value exceeds the mean value

Energy Type	% LLSOAs/IGZs where Mean > 50th percentile	% LLSOAs/IGZs where Mean > 60th percentile	% LLSOAs/IGZs where Mean > 70th percentile
Gas	97%	12%	0.2%
Profile 1 Electricity	100%	63%	1%
Profile 2 Electricity	95%	55%	6%

Figure 11 – Distribution of Profile 1 Electricity Consumption for one LLSOA



In light of these points the **recommendation is to use the median (50th percentile) as the benchmark statistic** for the average energy consumed in an LLSOA/IGZ. The median will ensure that 50% of households are categorised as over-consuming and 50% under-consuming in each LLSOA/IGZ.

The following charts (Figures 12-15) show the banded distribution of consumption around the median.

Figure 12 – Distribution of gas consumption values to show difference from median

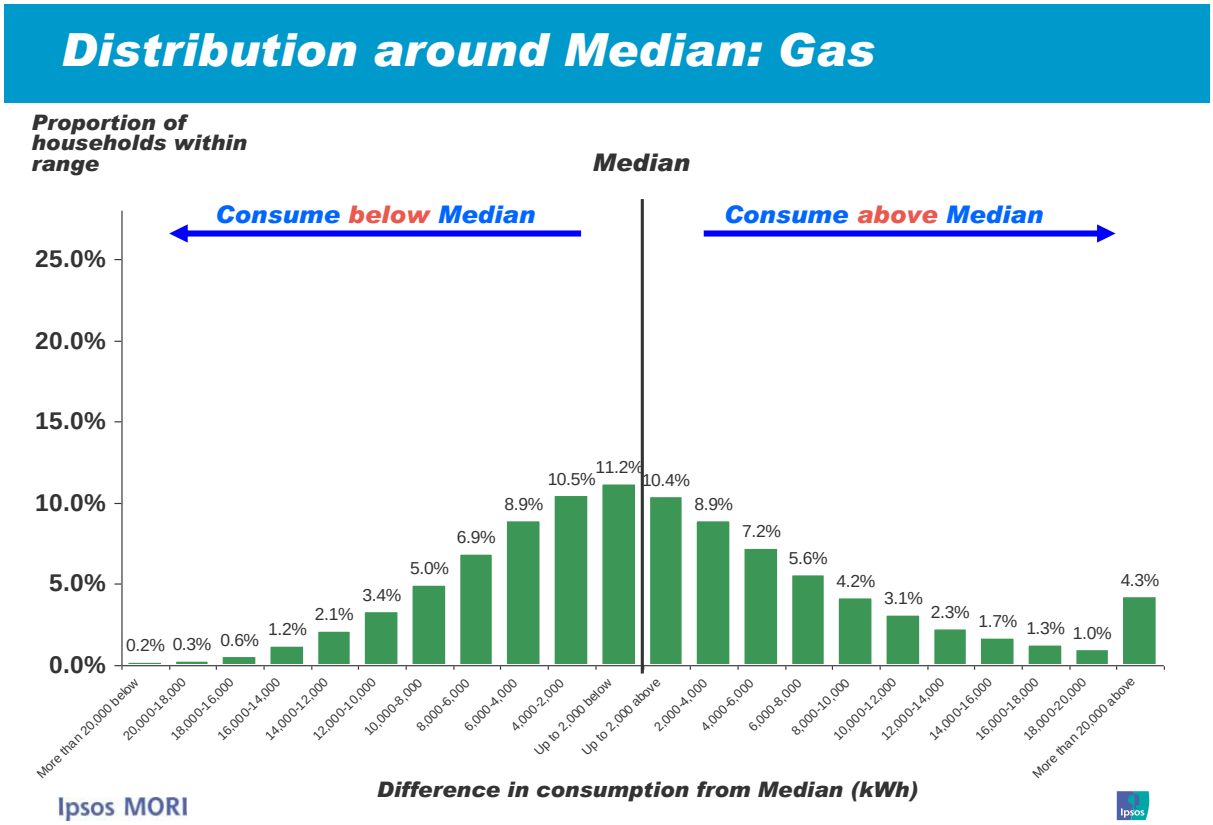


Figure 13 – Distribution of Profile 1 electricity consumption values to show difference from median

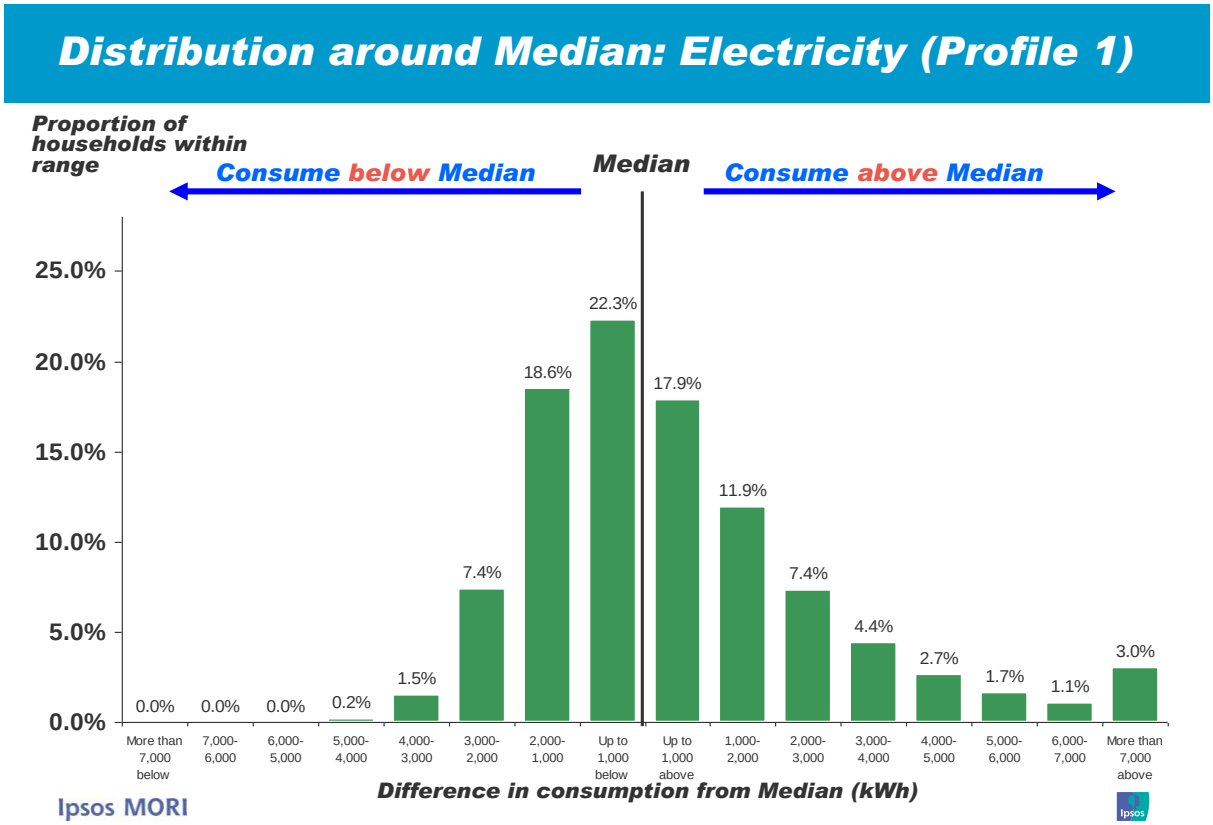


Figure 14 – Distribution of Profile 2 electricity consumption values to show difference from median

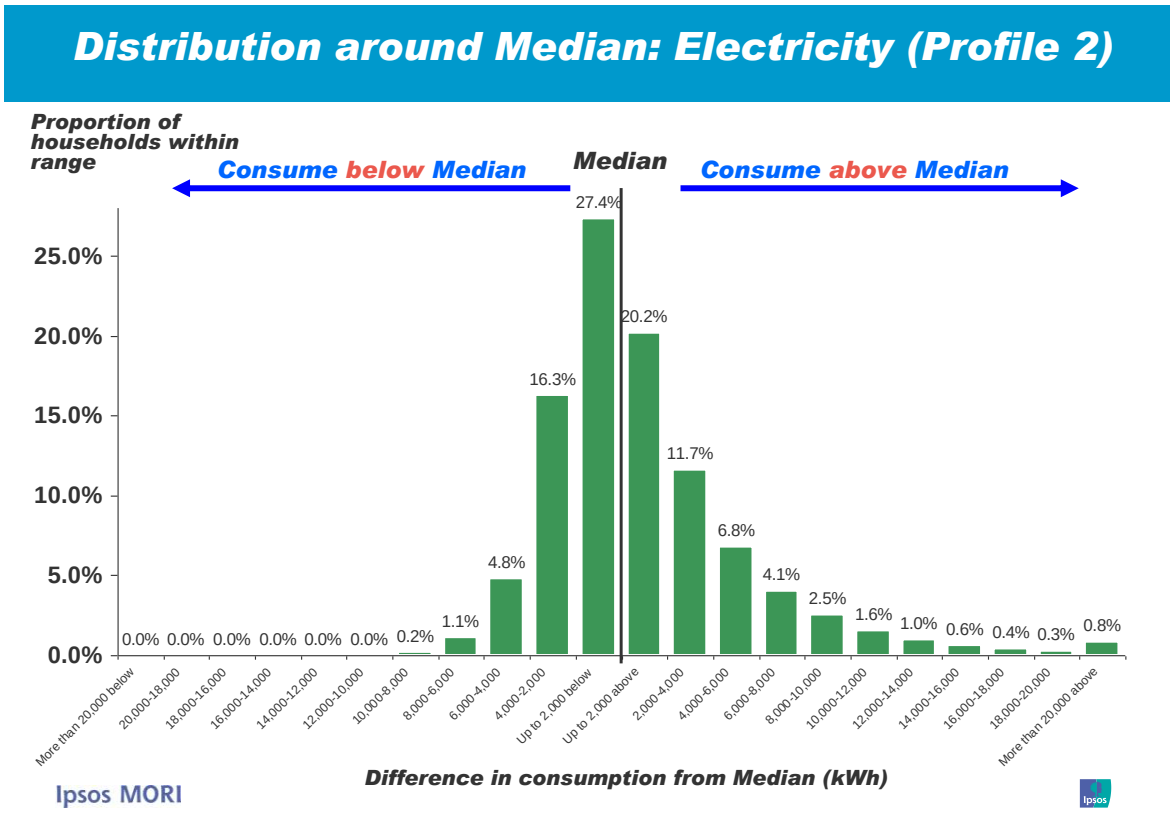
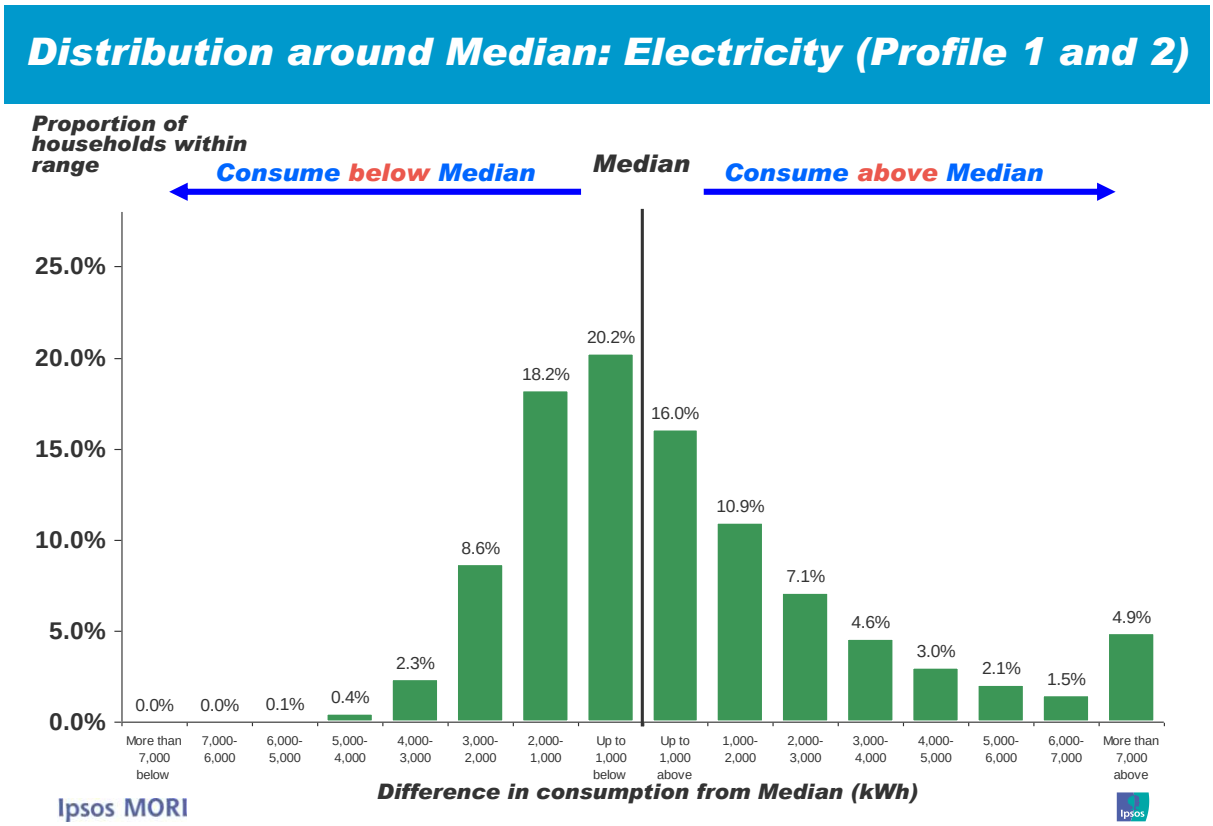


Figure 15 – Distribution of electricity consumption (Profile 1 and 2 combined) values to show difference from median



The *optimal* benchmark, based on consumer reactions and multivariate regression analysis, would be a median energy usage for participants living within a particular property type (detached, semi-detached, terraced), property size (according to number of bedrooms) and household composition (working couple, family with children, retired etc). The specificity of such a benchmark would increase participants' confidence in the relevance of the information to them and their lifestyle, and regression analysis has shown these variables to be key determinants of energy usage. However, the availability of this data at a household level to energy suppliers and the complexity of varying benchmarks in this way means a **median value for a specific local area** is likely to be the most appropriate, and realistic, benchmark to select for inclusion within bills. As discussed through this report, participants preferred to receive information specific to their local area as this would allow them to make their own judgements about the property and household types included within the calculation and to decide on its relevance to their own situation.

On the back of this recommendation, energy consumption benchmarks, based on median values, have been calculated for all LLSOAs, and IGZs in Great Britain. The median values have been calculated from meter point level datasets provided by the Department of Energy and Climate Change. Median energy consumption values have been calculated for gas and electricity separately. The electricity data has been further split into ordinary domestic (profile 1) and Economy 7 domestic (profile 2) consumption. The Economy 7 benchmark can be used to hypothesise about consumption for off-gas grid locations, although reactions of participants in these areas were not included within the qualitative research.

Details on the cleaning and editing of these datasets, including assumptions on which datapoints to include and exclude for the calculation of the local area benchmarks, are included in Appendix D.

Conclusions

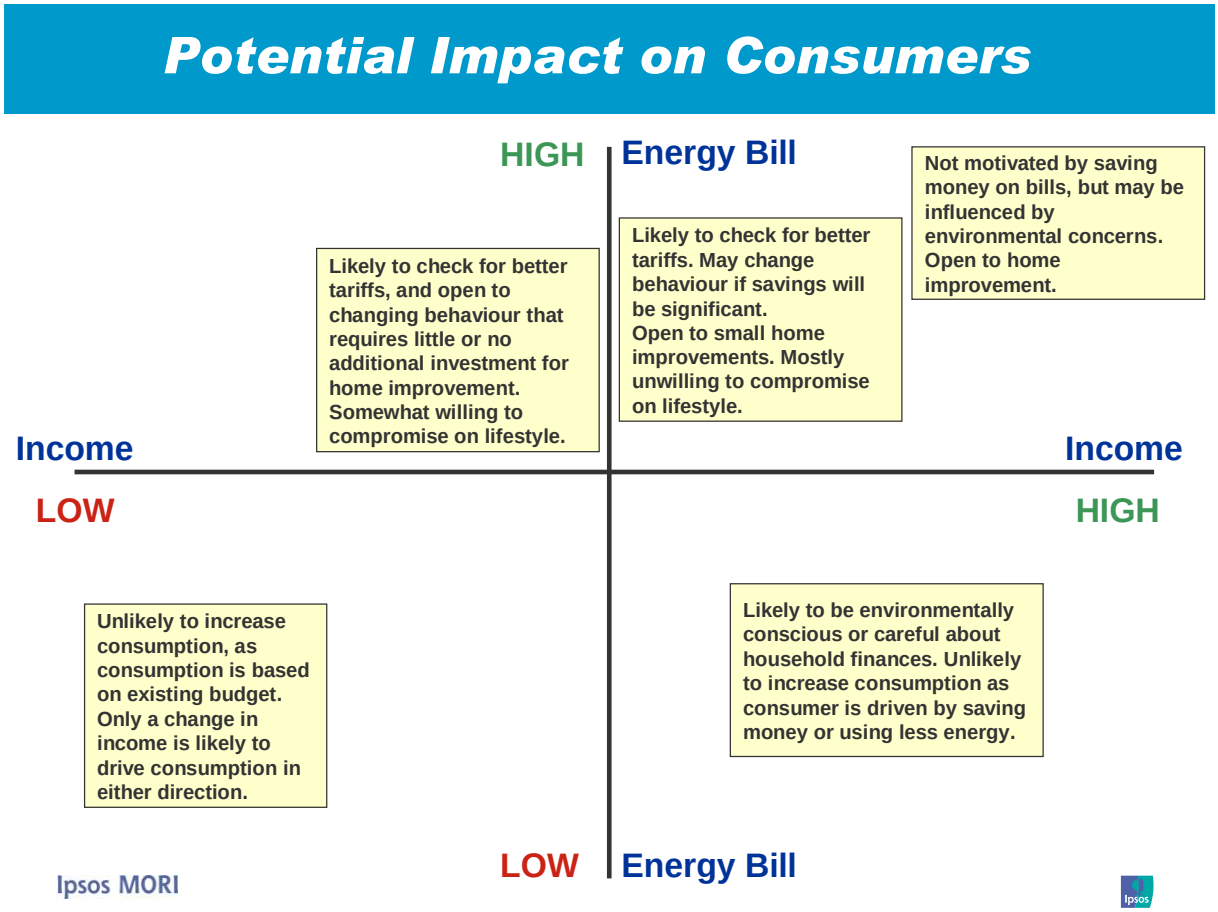
3. Conclusions

Most participants welcomed benchmark information on their bills, though their initial and primary reaction would more likely be to **attempt to secure a cheaper tariff than changing their energy consumption behaviour**. That said, a few participants felt they would consider reducing their energy use in direct response to the benchmark, while others would only do so if they were still substantially above the benchmark after having switched. To this end this research found that the benchmarks could lead to greater engagement with the bill which in turn has the potential to lead to behaviour change.

The reactions of different participants highlighted that the **impact of an energy consumption benchmark** would be dependent on a number of factors including the visibility of this information within the bill, its perceived credibility and how the household's usage compares against the benchmark. This research finds that other factors like household income, general financial behaviour and concern for the environment could also affect how participants would act on the information provided.

The behaviour of participants in reaction to the benchmark would most likely be determined by two variables – household income and the difference between the household's energy bill and the benchmark for the area.

Figure 16: Potential impact of benchmark data on consumers



The provision of a benchmark would be **highly unlikely to have a negative effect on low income participants** as they have a high awareness of how little fuel they use and how it falls short of their needs. These participants stressed that their level of consumption is dependent on their overall financial circumstances rather than the desire to consume less energy.

While the views of low-consuming households captured through these interviews were universal on this front, it is worth bearing in mind the relatively low numbers of these participants engaged through this research. Indeed, for a robust conclusion on the impact of a benchmark for any type of consumer, whether above or below the benchmark, a trial would need to be conducted to test the real impact of the information provided on actual usage over a period of time. This research is limited by its hypothetical assessment of whether energy usage would be likely to change in response to the provision of a consumption benchmark.

Participants need a **relevant, clear and credible benchmark** to be able to engage with the issue of energy consumption. Participants thought this could be achieved through appropriate placement of the information and by using terms they understand. The following steps are identified by participants as ways of helping to maximise the impact of the benchmark.

Placement of information

- Including the benchmark within the energy bill would help increase its relevance as participants tended to think about energy consumption when they pay their energy bills.

- Within the energy bill, participants thought the benchmark needed to be prominently displayed on the front page, or next to the 'amount to be paid' section. Participants thought this placement would help them to make the connection between energy consumption and saving money.

Credibility of information

- Participants viewed energy bills as official communication from energy suppliers. Information on the bill itself was trusted, and placement in the energy bill would increase the credibility of the information.

- Participants felt that the benchmark should be linked to an independent authority such as the government or an agency such as Ofgem. They felt this increased the credibility of the information.

Relevance of information

- For information to be relevant it would need to use terms that participants use when thinking about energy consumption. Participants tended to think in terms of money, rather than kWh, and using kWh could alienate or confuse them.

- Participants would need to be able to see how significant the difference is, and they believed this would be better presented through annual, rather than monthly or daily figures. As annual differences comprised bigger numbers, participants felt they would take these more seriously.

- Participants would like the information to be accompanied with advice on how energy consumption could be reduced. They felt a link to a website or a free-phone number would provide them with a clear direction for further information.

Clarity of information

- Participants preferred to know what the 'average home' in their area is considered to be in terms of number of rooms and number of inhabitants. Participants would then be confident to make a judgement themselves about how similar they would expect their property and household to be to the average.

- This research suggested that the use of an average figure was likely to be more powerful than providing data based on percentiles to show the highest and lowest consumption levels. Most participants did not understand what percentiles mean, and because of the visual representation of percentiles, tended to assume that they were in the 'middle'. This research therefore showed that it is less likely that consumers would alter their energy consumption as a result of receiving the percentile data than the local area average. Participants were even more likely to interpret a benchmark based on percentile data as an indication of tariff variation rather than an indication of different levels of usage. The research found that this risk of misunderstanding and misinterpretation is reduced when using a simple average comparison for the benchmark.

- Participants preferred charts, as they were eye-catching and easy to understand. Participants wanted the chart to be simple, based on either solid-block charts or a simple visual like coins. Participants also stressed that the chart should be clearly labelled, with the amount of the average bill and the household's bill shown prominently.

Appropriate benchmark type

- The participant reactions captured through this research point to a form of central tendency as the most appropriate benchmark to present on energy bills. From a statistical perspective the most appropriate type of average to use would be a median (50^{th} percentile). This is because it was a more robust measure for dealing with outlying values in the consumption datasets and also produced figures which led a greater proportion of participants to be shown as consuming above average.

The practical recommendations which can be taken from this research for the design and presentation of energy consumption benchmarks have been drawn together into a 'communications tookit'. This is presented in the next section of this report and intends to inform policy makers and energy suppliers of the key findings from the research.

Communications Toolkit

5. Communications Toolkit

This toolkit is intended to inform policy makers and energy suppliers of the key findings from this research. It was conducted by Ipsos MORI and explored the potential for benchmark data presented through consumer bills to impact on energy consumption behaviour. This research has been commissioned by the Department of Energy and Climate Change (DECC).

To provide a recommendation on the most appropriate benchmarks to incorporate, and the most powerful way of displaying these, within consumer bills, this research involved the following stages:

In-depth in-home interviews with participants to test reactions to relevant benchmark data, presented in different forms;

Analysis of electricity and gas consumption across Great Britain to understand the factors influencing levels of consumption and the production of a set of appropriate benchmarks based on the findings from the participant research.

Supported by preliminary research:

A **review of existing evidence** on presenting energy consumption benchmarks and its likely impact on consumer behaviour;

Discussion groups with participants to test the most appropriate presentation of a benchmark;

What level of interest is there in benchmark data?

Can it impact on consumer behaviour?

Overall this research has found there was an appetite for energy consumption benchmarks to be presented within bills. On the whole participants were interested in receiving this data. Among participants who were not interested, their reception to the provision of this data would not be hostile. This was true across all groups of participants, including those on pre-payment meters.

Participants would trust the benchmark value if it was communicated via an energy bill. Participants felt the credibility of the information could be further improved through endorsement from government or an industry watchdog, such as Ofgem.

However, the participant reactions captured through this research indicated that the benchmark may not always be used as intended to make judgements about levels of personal energy consumption and may not directly lead to behaviour changes. Instead, participants said the benchmark would be more likely to encourage them to consider alternate suppliers or to investigate cheaper tariff options. A few participants felt they would consider reducing their energy use in response to the benchmark, while others would only do so if they were still substantially above the benchmark after having switched. To this end this research found that the benchmarks could lead to greater engagement with the bill which in turn could lead to behaviour change.

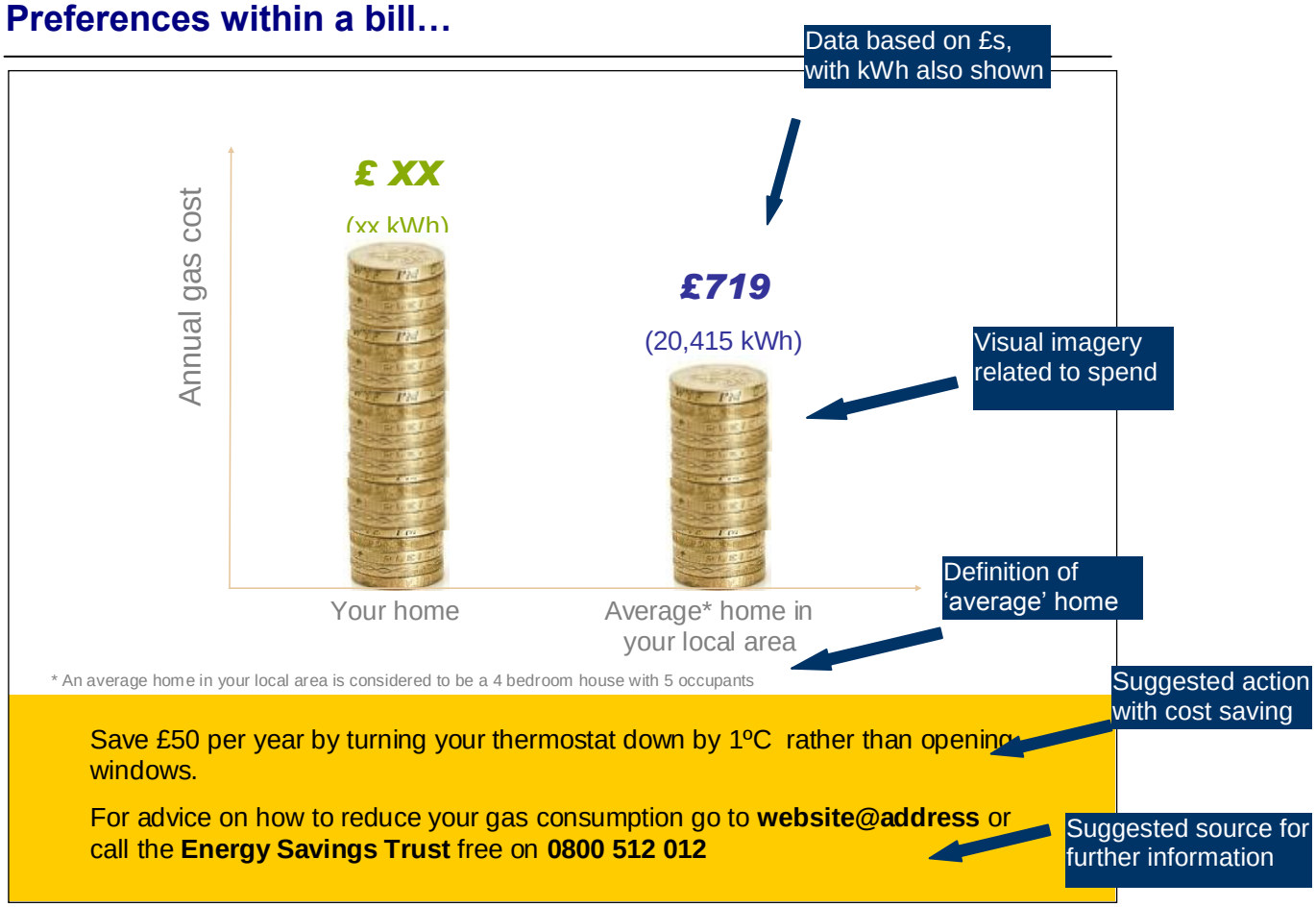
Based on the findings of this research, this toolkit highlights the recommended **DO's** and **DONT's** for selecting benchmark data and for presenting this within consumer bills in order to maximise the potential for it to impact on consumer behaviours.

A mock-up of the **PREFERRED PRESENTATION** based on participant reactions is provided at the end of this toolkit.

	DO	Don't, things to avoid…
Selecting appropriate benchmarks	Use MEDIAN data Calculate median usage across as LOCALISED an area as possible Calculate ANNUAL median usage *If possible….* *Calculate median usage across customers from one supplier*	Use percentiles Use straight means, as a greater proportion of consumers will be shown to be below the mean
Placement of benchmark data	Include within bill Include on FRONT PAGE of bill Include close to bill amount	Place benchmark data within detailed final page of bill Provide benchmark data on separate document
Presenting benchmark data	Use BAR CHART format Use VISUAL IMAGERY in place of blocked bars – coins are most effective Use COLOUR Present COST data (£) *If possible…* *Present usage data (kWh) alongside cost data*	Only present usage (kWh) data, as participants do not engage with this Provide only a text statement (if this is only option ensure it is bold, large, in colour, and next to bill amount) Use red colour, as portrays negative message
Provision of supporting data	*If possible include…* *Information on what 'average' home in area is considered to be e.g. 2 bedroom, 3 occupants* *Endorsement from government or Ofgem that data is considered*	Provide technical detail behind calculation of benchmarks, as considered unnecessary detail Provide a definition of the local area, as participants say they would rather rely on their own perception

	valid and reliable	
	DO's	**DONT's, things to avoid…**
Inclusion of additional information	Present tips on reducing energy usage Revise suggested tips on annual basis Present RANGE OF TIPS, from zero-cost behaviour changes to investments in energy savings appliances and measures Provide expected annual COST SAVINGS for suggested behaviour changes and investments Provide information on average cost of usage of common appliances *e.g. it costs £X every time you boil a full kettle* Include WEBSITE and freephone advice lines for further information Use BOLD, COLOURFUL font for this information Place additional information DIRECTLY BELOW BENCHMARK data *If possible…* *Provide independent/ government links for further advice, but can be supplier-based if necessary* *Consider a positive feedback message for low-consuming households (although suggest further testing of this with fuel-poor)*	Set targets for energy use based on average household consumption (a few participants are interested in setting their own targets and tracking progress against these through bills)

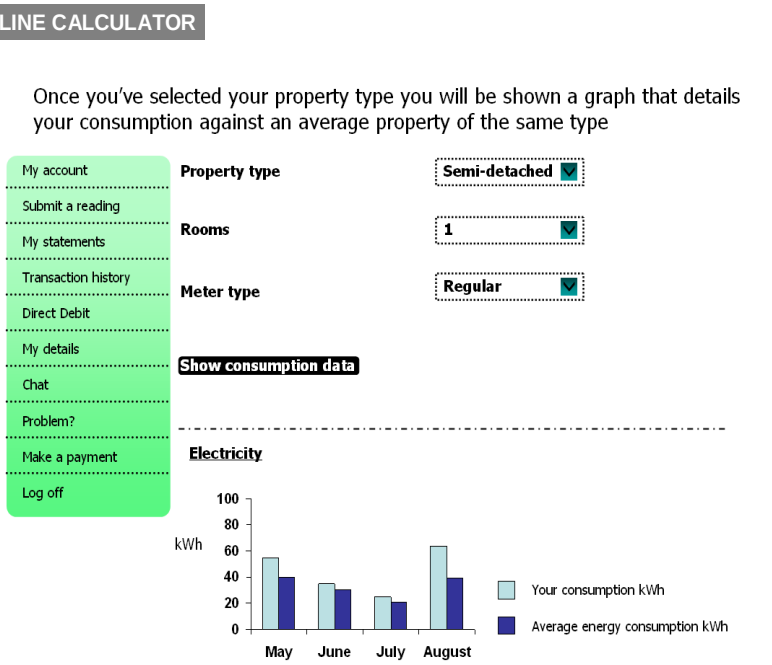
Preferences within a bill…



The preferred online calculator

Some participants felt that an online calculator tool would be preferred, and would allow them to enter tailored information about their property and household to generate individually relevant benchmark data.

This tool could also allow participants to test the impact of various energy efficiency measures (e.g. cavity wall insulation) on their expected household consumption.



However, in order to encourage participants to access an online tool, the research found that an **engaging presentation was still required within the bill** itself. The direct link between the bill amount and the benchmark is vital to engage participants with this information. They are unlikely to follow a link to an online tool without this trigger.

Appendix

Appendix A: Primary research methodology

Discussion groups with participants

Six ninety-minute group discussions were held in the following locations on 12th and 13th January 2011:

Stockport - a suburban area with mixed population and housing providing a mix of payment types

Banbury - a rural area with low levels of deprivation, a predominance of detached housing and a high proportion of direct debit participants (although not exclusively)

Birmingham – an urban area with high levels of deprivation, terraced housing, and an opportunity to recruit PPM participants (although not exclusively)

Each group was attended by 8-10 participants. The table below sets out the characteristics of the respondents included in each group.

	Gender	Engagement	SEG	`Payment	Age	Children in HH
1. Stockport	Mix	Mix	C1C2	At least 3 Quarterly payers	24-39	Natural fall out
2. Stockport					40-64	Natural fall out
3. Banbury			ABC1	At least 3 DD payers	24-39	Yes (min. 3)
4. Banbury					65+	Natural fall out
5. Birmingham			C2DE	Max. 3 PPM participants	40-64	Yes (min. 3)
6. Birmingham					65+	Natural fall out

In-depth in-home interviews

Interview locations

49 in-depth in-home interviews were conducted during February 2011. The interviews were conducted across six locations. Three of these locations were chosen for the heterogeneity of the properties in the area. Respondents from these areas were recruited from a broad mix of property types and ages (across the full range of flats, terraced, semi-detached, detached and also from different periods, including new build homes).

- Ipswich
- Greenwich
- East Northampton

Three locations were chosen due to the homogeneity of the properties in the area. Respondents from these areas were recruited from similar types and age properties. For instance, all respondents in an area lived in detached and semi-detached properties or all respondents lived in flats.

- Tandridge
- North Wiltshire
- East Renfrewshire

Selecting respondents

Respondents were recruited on-street for this research. Quotas were set at the recruitment stage to ensure coverage of many lifestyle and demographic factors, including:

- **Gender** – the quotas were weighted towards female respondents as the review of existing research showed women to be less trusting of statistical information
- **Social grade**
- **Age**
- **Tenure** – to provide a mix of owner occupiers, private renters and social renters
- **Payment type** – in each area there were a mix of direct debit and payment on demand participants. There were also two pre-payment participants per area (this limit was set due to the different form of billing received by these participants i.e. an annual statement rather than a regular bill).
- **Trust in energy suppliers**

Each interview lasted approximately 1 hour with some interviews taking place with paired respondents to provide views from different members of the household.

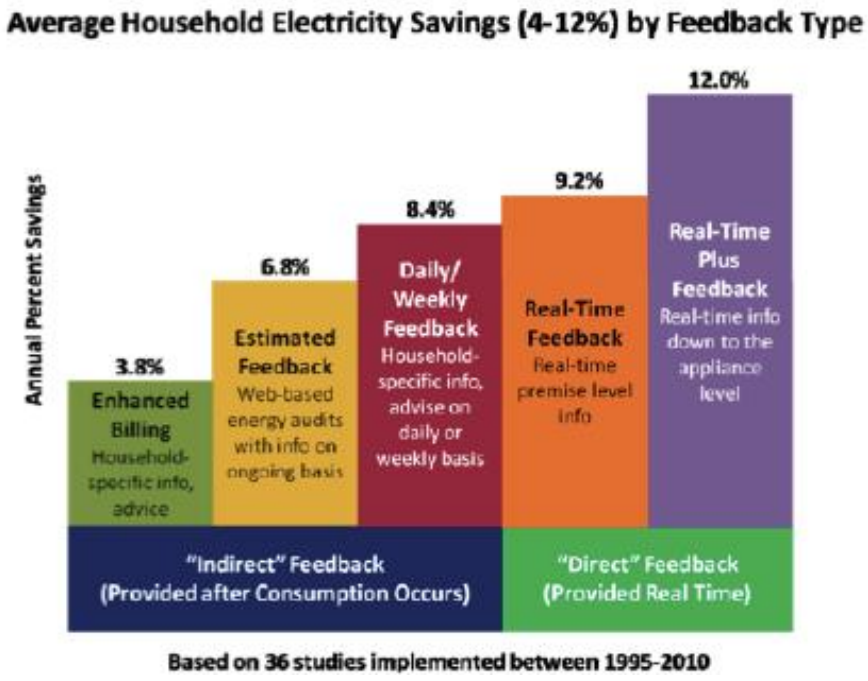
Appendix B: Review of existing literature

A review of existing literature

Introduction

This report reviews previous research conducted around consumer reactions to energy consumption benchmarks. It also reviews studies into effective messaging for encouraging attitudinal and behavioural change and the likely impact of energy benchmarks on consumer behaviour. To date a lot of this research has taken place outside of the UK, particularly in North America, although this report does draw on research conducted with UK participants where possible.

The Centre for Sustainable Energy estimate that improvements to domestic customer feedback on energy consumption have the potential to deliver sustained energy savings of around 5-15% for many customers[8]. This does, however, incorporate a range of feedback techniques, including real-time displays. Another review conducted by the University of Colorado[9] suggests indirect feedback via enhanced billing more specifically may have a lower potential for changing behaviour (estimated at 3.8% annual savings as shown in the diagram below). Other research[10] estimates enhanced billing information has the ability to generate savings in the region of 0-10% with the variation dependent on the context in which the comparative data is given and the quality of this information. This review looks at some of these different presentations and the feedback collected on them to date.



International research reviewed by the Centre for Sustainable Energy in their report to Ofgem (2003) shows that participants are motivated to act to reduce their energy consumption through the presentation of graphs and bar-charts which compare their consumption with other households on bills. However,

[8] Roberts, S., and Baker, W. (2003) Towards Effective Energy Information: Improving consumer feedback on energy consumption. A report to Ofgem. Centre for Sustainable Energy

[9] Ehrhardt-Martinez, K (2010). The Persistence of Feedback-Induced Energy Savings in the Residential Sector: Evidence from a Meta-Review.

[10] Darby, S, 'Making it obvious: designing feedback into energy consumption' 2004 and Fischer, C 'Feedback on household electricity consumption: a tool for saving energy', *Energy Efficiency*, 2008

research among UK participants has not shown the same appetite for normative data. UK participants have been sceptical about the validity of energy comparisons with average levels of consumption.

The Centre for Sustainable Energy report stresses the importance of engaging participants in the design of feedback information. It is important to test not only the preferred visual presentation of the data but also the comprehension of the data.

This review of existing evidence starts by considering consumer engagement with numerical data generally and then continues to consider reactions to different presentations of energy consumption data. It focuses on three main areas:

1) Consumer understanding of, and trust in, numeric information

2) Consumer preferences for presenting benchmark data

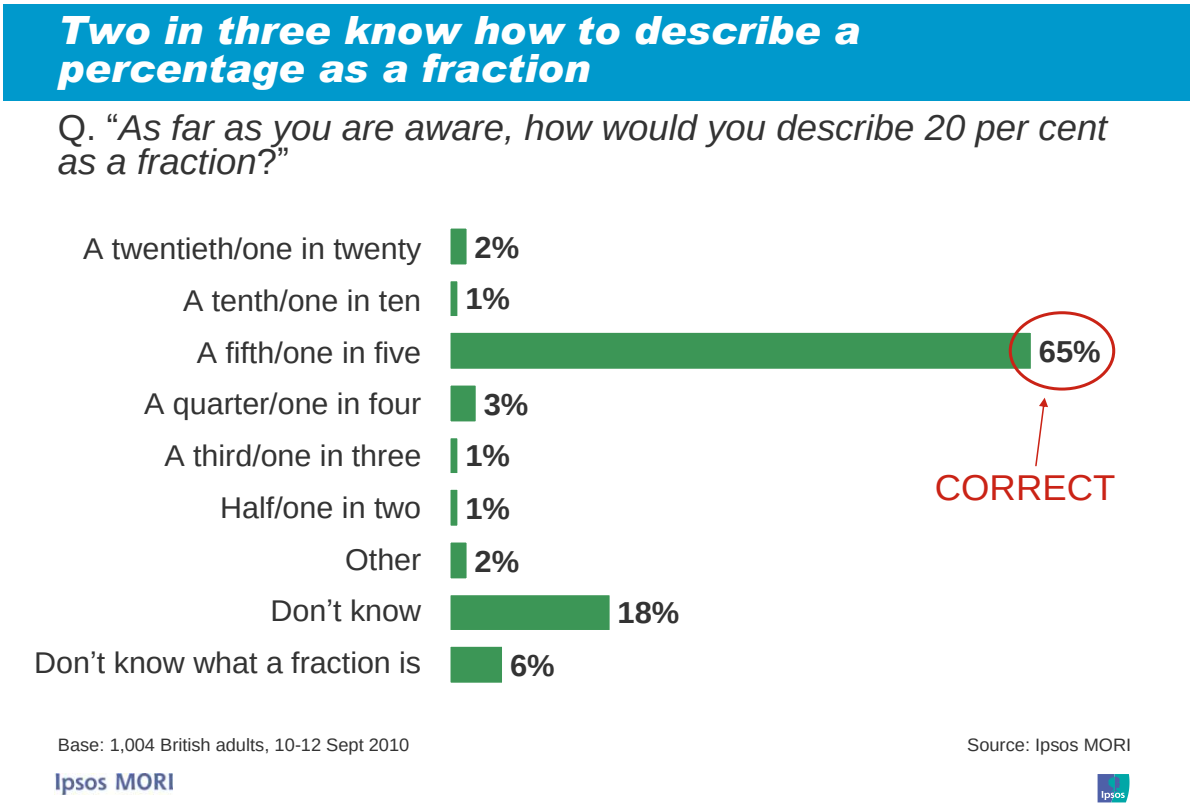
3) Motivating message frames for encouraging environmental behaviour change

Throughout this review the implications for the design and focus of the current benchmarking research for DECC are considered.

1. Consumer understanding of, and trust in, numeric information

There are likely to be major barriers to consumer comprehension of benchmark data given research shows many members of the general public have a limited ability to interpret numeric information.

For instance, when a nationally representative sample of the general public were asked what 20% is as a fraction, one in three (35%) either gave the wrong answer or did not know[11].

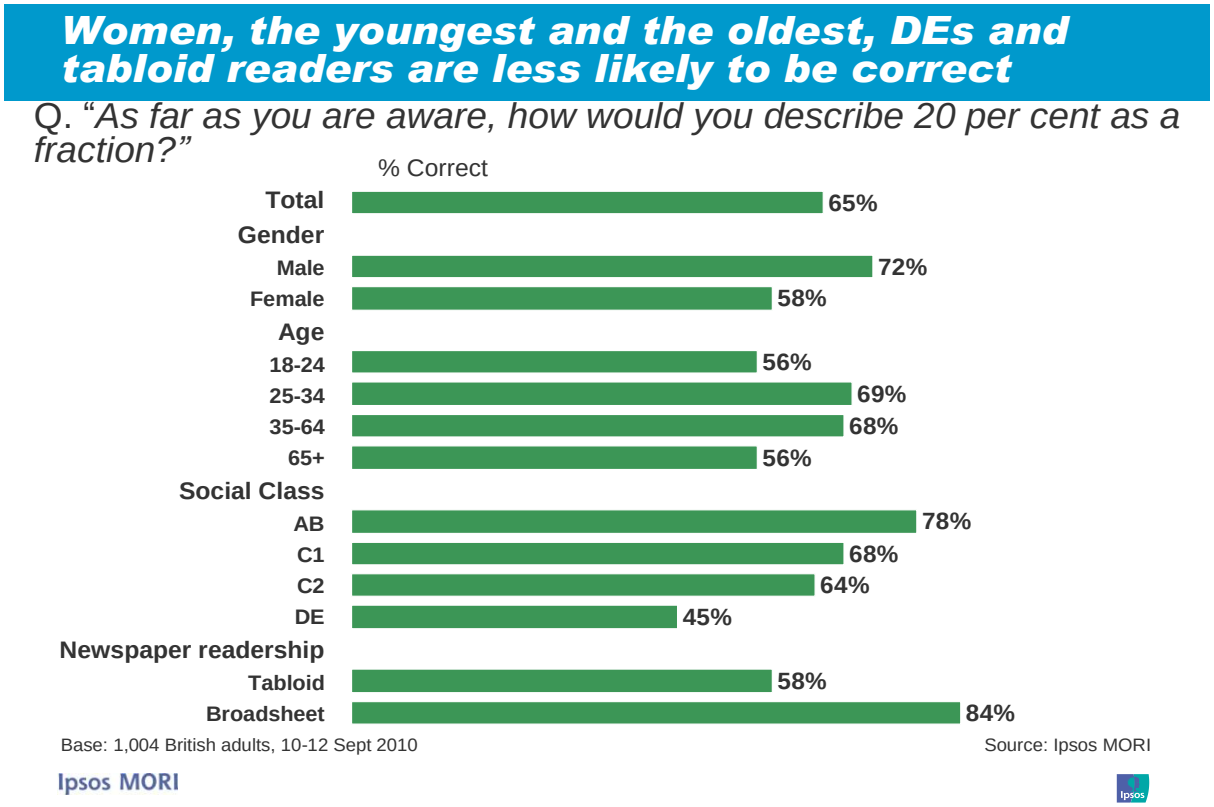


[11] Trust of statistics/official figures questions: Ipsos MORI interviewed a representative sample of 1,009 adults aged 18+ across Great Britain. Interviews were conducted by telephone from 15-17 Oct 2010. Data are weighted to match the profile of the population.

The qualitative element of this research will therefore need to test the most commonly understood form for communicating data i.e. whether fractions, percentages, text or visual descriptions are most comprehensive to participants.

It will be important for benchmark data to be communicated in a format which is universally understood. We therefore recommend that age and social grade are key factors in the recruitment criteria for the qualitative research as this will ensure inclusion of groups of people who are most likely to struggle with the interpretation of numeric data.

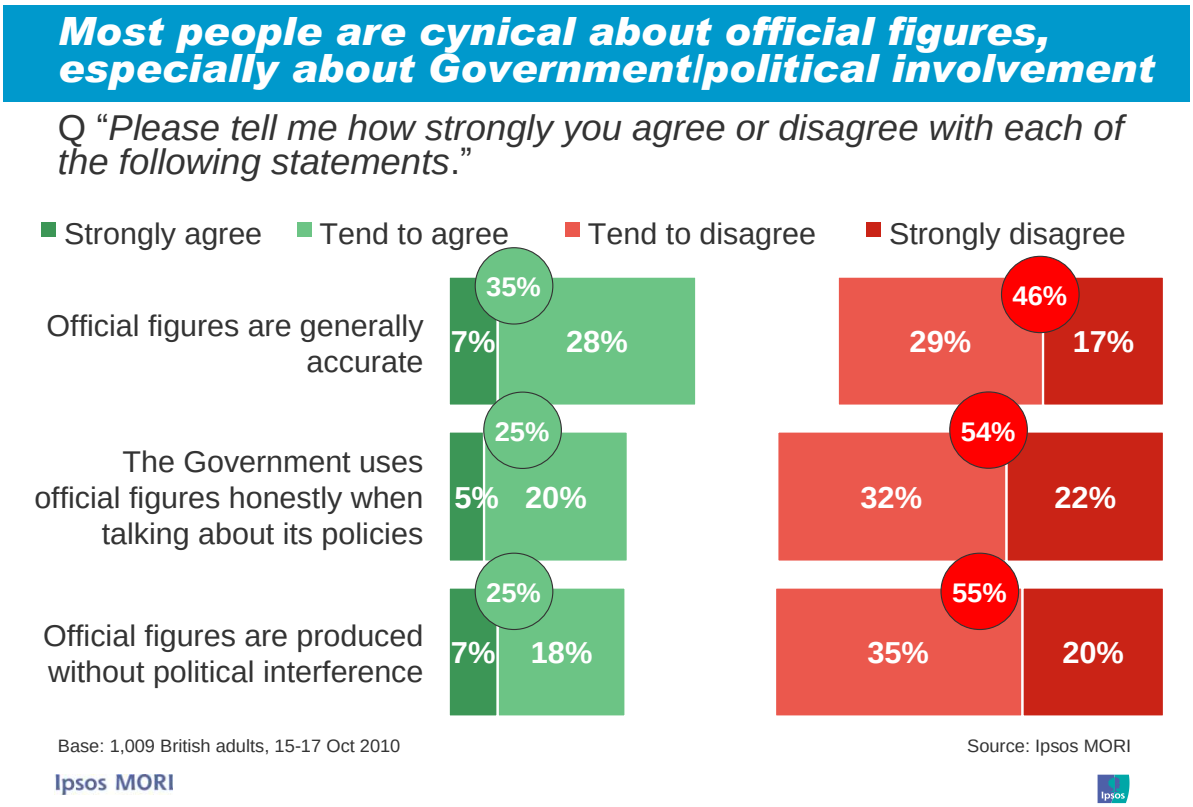
Ipsos MORI's research shows (see chart below) that there are certain groups of people who are less likely to be able to convert a percentage into a fraction. These groups are women, people aged 18 to 24 and over 65 and people in lower social grades.



Trust in statistics

The potential for energy benchmarks to change participants' attitudes and behaviours will not only depend on their ability to interpret the numeric data correctly but also the extent to which they are willing to place their trust in the data presented to them. Research suggests there is considerable mistrust of statistics among the public. While the research conducted to date often focuses on government sources of information, it is likely that data distributed by energy companies could face a similar challenge.

An Ipsos MORI survey shows that more of the public disagree that official figures are generally accurate than agree that they are (46% vs. 35% respectively). The public are suspicious of political involvement in statistics; over half of people (55%) disagree that official figures are produced without political interference.



Both quantitative and qualitative research[12] exploring public trust in statistics confirms that the most commonly cited reason for not trusting official statistics is that they contradict with people's personal experiences. Self-validation, through personal knowledge and experience is used as the basis for determining trust when other determinants are absent or in doubt. This poses a challenge for benchmark data which may contradict consumer's self-perceptions of their own energy use and that of other households. Indeed, the Centre for Sustainable Energy report (2003) stresses that participants' act if they have feedback specific to their circumstances and so this is a vital consideration.

Differences across different participants

Gender, age, social grade and location are shown to be key factors affecting trust in statistics[5]. The following groups of people are most likely to have trust in statistics:

- younger
- men
- higher social grade
- higher level of education
- people living in South of England

It may be worth considering these factors in the recruitment of participants for the in-depth in-home interviews. One suggested approach would be to weight the sample towards those groups who tend to be less trusting of official data in order to test what information and messages would encourage them to take notice of the benchmark information.

2. Consumer preferences for presenting benchmark data

[12] Public Confidence in Official Statistics- A qualitative study on behalf of the Office for National Statistics and the Statistics Commission, 2005

Different studies have tested a range of presentations for energy consumption benchmark data. These can be used as the basis for stimulus for the qualitative research with householders being conducted now by DECC. It needs to be decided, from the review of the different presentations given below, whether any designs should be excluded from DECC's research on the basis of prior findings which have found them either ineffective in encouraging behaviour change or difficult to interpret.

Research conducted by the Centre for Energy and Environmental Policy[13] tested range of different presentations for energy comparison data. These are presented below.

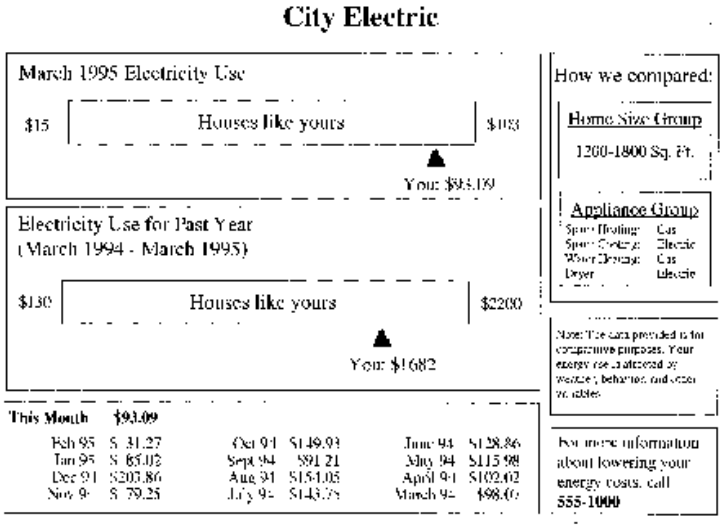


Figure 1 shows the recipient's total bill (in dollars) as a point along a range of customer bills within a single comparison group (houses in the same square footage group). Both a monthly and an annual (past 12 months) comparison are incorporated to allow for different evaluations of the individual to the group. Additionally, a table of historic monthly cost and kWh consumption is included to facilitate self-comparison.

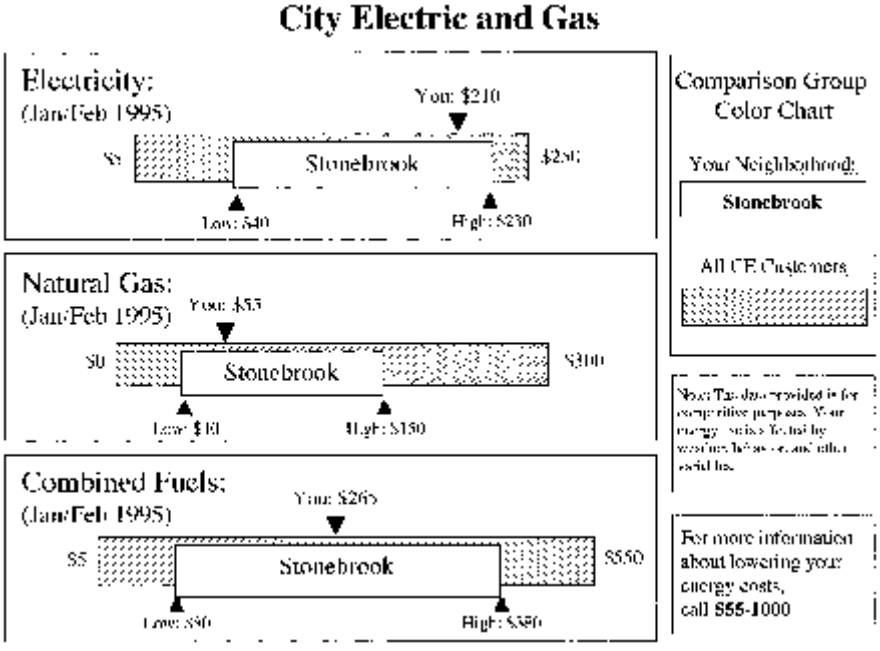
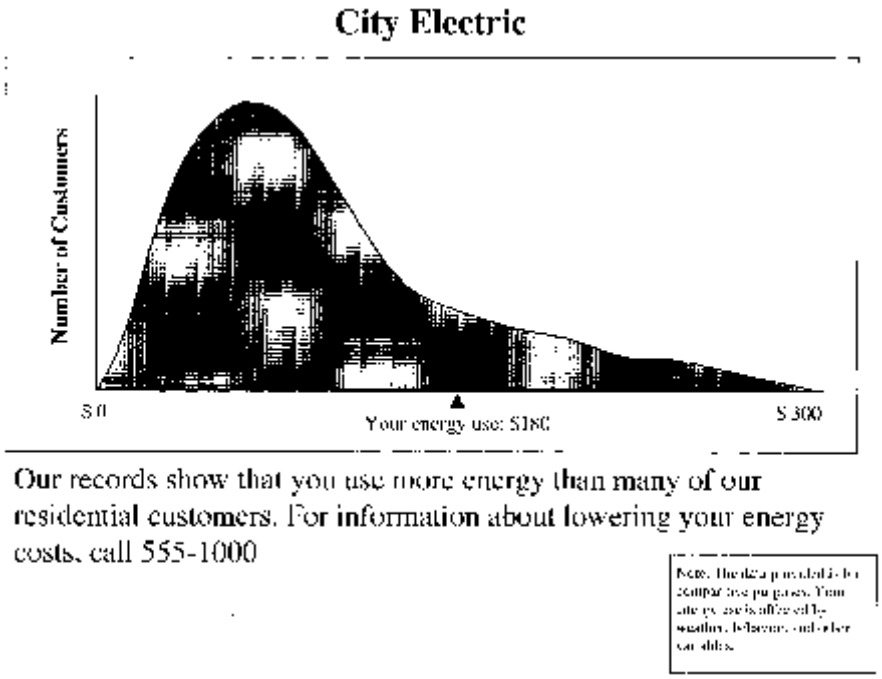


Figure 2 includes individual bars for electricity and gas, as well as a combined fuel comparison. Data is aggregated on a bi-monthly basis instead of monthly or annually. This display also shows the recipient in comparison with two groups (the neighbourhood and the entire customer base) by overlaying two bars in one graph.

[13] Egan, Kempton, Eide, Lord et al, How customers interpret and use omparative graphics of their energy use, *Centre for Energy and Environmental Policy*

Figure 3 shows the recipient as a point on a distribution curve of the comparison group.

This research, conducted in the US, found the bar charts were the preferred presentation design. Figure 3 was the least favourably received presentation and was not immediately understood by participants. Some participants were unable to interpret the implications of the bell curve for their own level of consumption leading them to misunderstand that they were considered to be over-consuming relative to other participants. There were however favourable responses to the text statement included at the bottom of Figure 3.



Further tests were conducted on the following graphics which aimed to simplify the presentations.

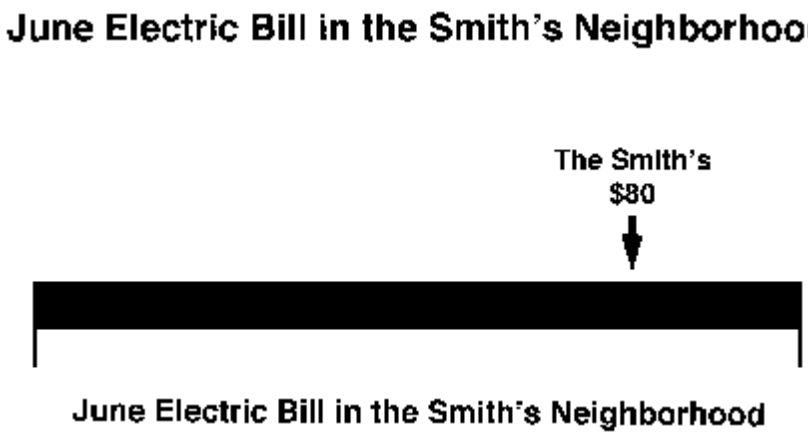


Figure 4 intended to test participants comprehension of basic bar graph concept with additional endpoint labels

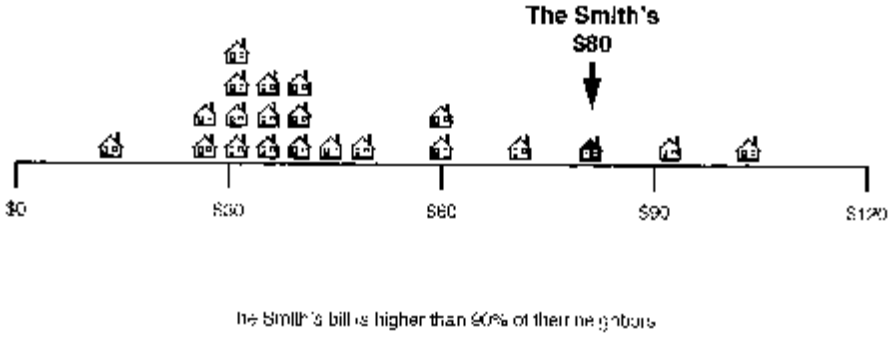


Figure 5 More user-friendly depiction of the bell curve

The majority of respondents were able to accurately understand these depictions and these were the preferred formats for the energy benchmark data (including preferred format for presenting bell curve).

A similar study of examples was conducted by Wilhite et al in Norway. The revised bell curve was less well received among these participants. The small houses were felt to be 'childish' and a general finding from this research was that participants can be distrustful of information presented simplistically unless it

is well explained. Research with UK participants (Ofgem report 2004[14]) also found pictorial representations, such as stacks of coins or different size houses, were rejected as 'gimmicky' and 'distracting'.

Additional presentation designs are shown below although there is little evidence of how these have been received by participants. These could therefore be useful designs to test with UK participants through DECC's research.

Figure 6

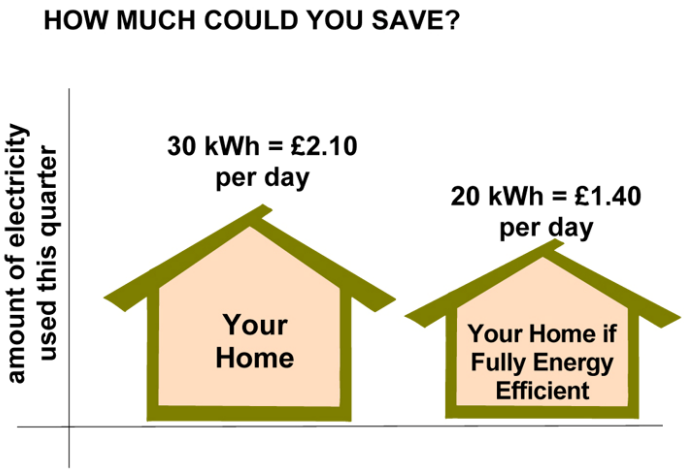
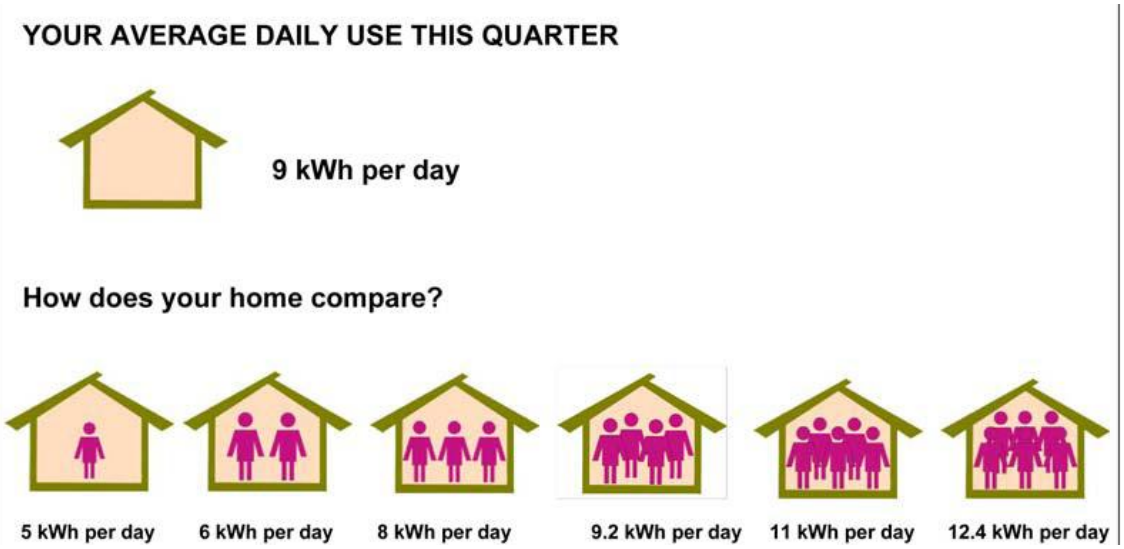


Figure 7



[14] Roberts, S (2004). Consumer Preferences for Improving Energy Consumption Feedback. A report to Ofgem. Centre for Sustainable Energy

Figure 8

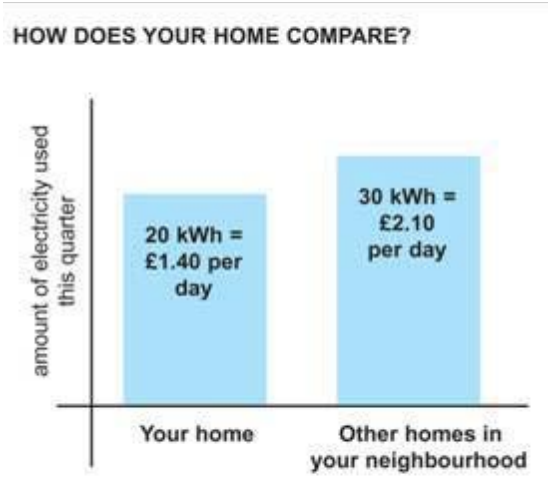


Figure9

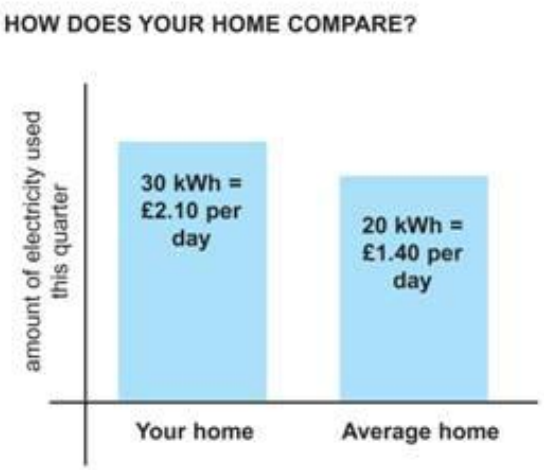


Figure 10

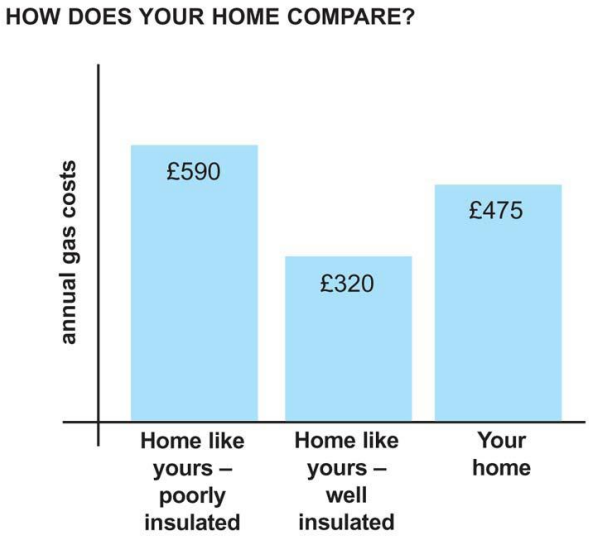
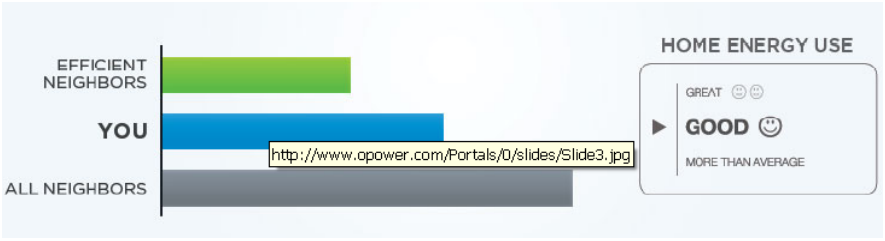


Figure 11



[15]

[15] Davis, M. What if behavioural interventions went national? A case study from oPower. http://www.stanford.edu/group/peec/cgi-bin/docs/events/2010/becc/presentations/4C_MattDavis.pdf

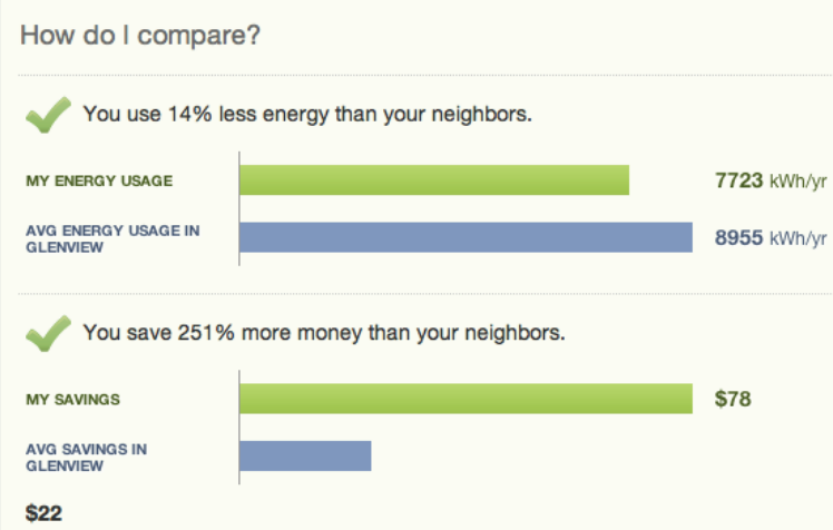


Figure 12[16]

Conedison ultility company in New York included the following graphic on participants bills although there is no evidence to suggest how favourably it has been received or how successful it has been in promoting behaviour change.

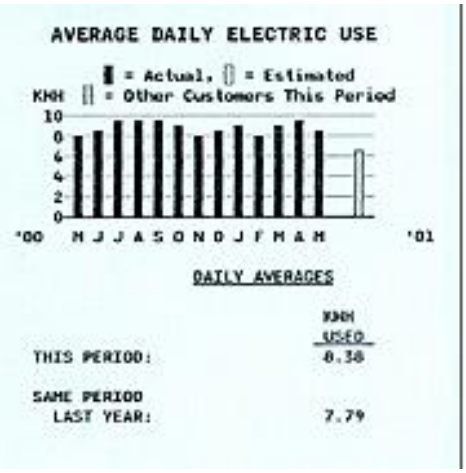


Figure 13 the right hand bar shows normative data for 'other customers this period' against bars for the bill recipients' month-on-month usage.

Most of the research to date points to the use of bar charts as the most appropriate format for communicating benchmark information to participants. However, the Centre for Energy and Environmental Policy paper[6] points out that although bar charts may be the preferable, and most familiar, format for participants, there is a need to consider how accurately these designs reflect the data. Unlike a bell curve, the bar chart does not show the distribution of the underlying data. Therefore small percentages at the end of the overall distribution can make the horizontal bar appear deceptively long leading to misleading consequences. For example Figure 14 below shows the 80th percentile as a mark halfway along the bar which whilst accurate is likely, in the participants mind, to be interpreted as average. There are therefore trade-offs between customer comprehension of graphics and the accuracy with which the display presents underlying data.

[16] Image used in Frank, A. Personal Energy Efficiency Rewards – A Behavioral Cocktail. Efficiency 2.0 http://www.stanford.edu/group/peec/cgi-bin/docs/events/2010/becc/presentations/4E_AndyFrank.pdf

Figure 14[13]

The Centre for Energy and Sustainability report for Ofgem (2003) stresses that comparison information should enable easy and stark comparison and this might require the use of clever graphics. For instance, bars representing 55 and 60 are difficult to distinguish visually on a scale available on a bill. Therefore, it would be better to show a baseline of 50 so that the bars appear as 5 and 10 unit respectively, emphasising the change and so increasing the potential for them to be a motivating call to action

Likely impacts of benchmark information on behaviour

Some participants do claim that they would be motivated to act to reduce their energy consumption through the presentation of graphs and bar-charts which compare their consumption with other households on bills. For instance, research in Norway among 2,000 households[17] suggests more than 85% would be interested in continuing to receive comparative information based on comparisons groups with similar household characteristics (number of people in household, type of dwelling, dwelling size, use of electric heating, hot water included in bill). This research found householders were able to correctly understand the benchmarks and that around three-quarters of them claimed they would be motivated to reduce their energy use if they were shown to be using more than average. In another study, over 70% of respondents said that they would take conservation action if they were shown to be over the 80th percentile of their comparison group[18].

However, research among UK participants has not shown the same appetite for normative data with participants sceptical about the validity of energy comparisons with average levels of consumption.

Studies have also shown that benchmarks may be less effective among low consuming households. These householders may feel deterred from conserving energy if they receive feedback that compares their energy use with higher participants and might even increase their consumption[19]. For instance, a study by Brandon & Lewis (1999) revealed that feedback led high and medium participants to save energy (3.7% and 2.5% respectively) and low participants to increase energy use (by 10.7%). This problem may be overcome by appropriate use of messages to deter increases among lower-consuming users.

A further barrier to sustained behaviour change across participants could be the lost novelty of feedback information once it becomes a norm on energy bills leading householders to fall back into old consumption habits[9]. Longitudinal research would be required to explore the validity of this hypothesis.

Different groups of participants are more or less likely to respond to enhanced billing information. A case-study of US energy company oPower's[20] approach to providing comparative data showed there to be particular groups of participants who are more and less likely to respond to enhanced billing. Comparative data was found to be most effective among:

- Low square footage households
- Households with fewer occupants

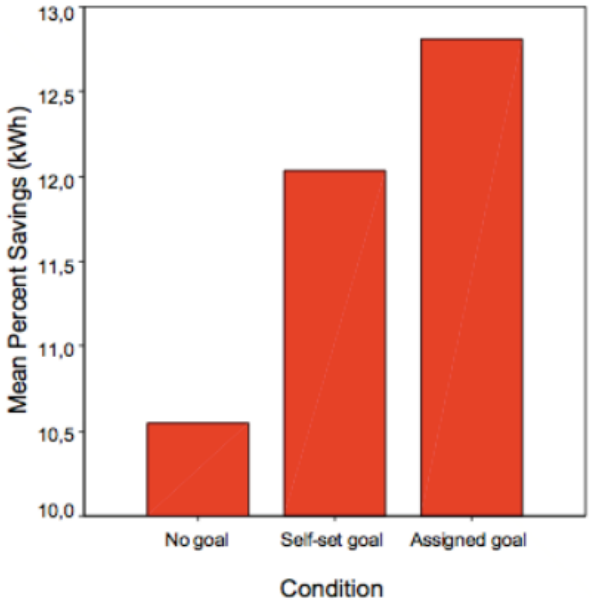
[17] Whilite, H et al (1999) Advances in the use of consumption feedback information in energy billing: the experiences of a Norwegian energy utility, ECEEE Summer Study Proceedings, 1999
[18] Darby, S 'The effectiveness of feedback on energy consumption', 2006 citing Lyer et al. 1998
[19] Fischer, C 'Feedback on household electricity consumption: a tool for saving energy', *Energy Efficiency*, 2008
[20] Davis, M. What if behavioural interventions went national? A case study from oPower. http://www.stanford.edu/group/peec/cgi-bin/docs/events/2010/becc/presentations/4C_MattDavis.pdf

- Older householders
- Higher energy users

It will be important for DECC's research to include a wide range of householders, covering the factors set out above, during the in-home in-depth interviews to explore the differing reactions to benchmark information.

It may be worth considering the scope of DECC's research into effective benchmarking and whether this extends to considering the inclusion of energy consumption targets within consumer bills. Goal-setting has been found to complement the effectiveness of feedback. In one study, where daily feedback was combined with a goal of a 10% reduction in gas use, participants achieved a 12.3% reduction. Another study[21], which combined tailored information and feedback with goal-setting found that households exposed to this combination of interventions saved energy more than the control group, which increased energy use.

Figure 15[22]

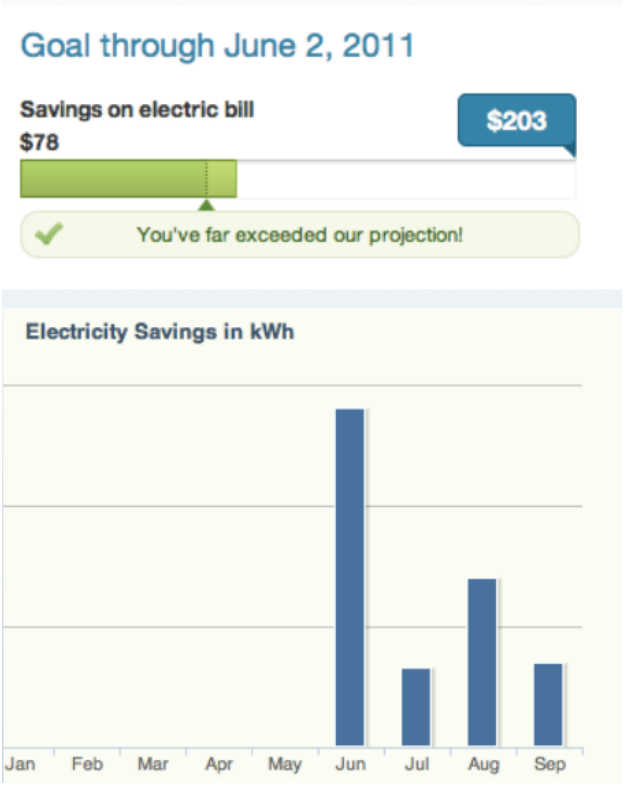


The Centre for Sustainable Energy report for Ofgem (2003) agrees that a target-based approach has potential to be very motivating for participants. A possible approach to presenting targets is provided below:

[21] Abrahmse et al 'The effect of tailored information, goal setting, and tailored feedback', *Journal of Environmental Psychology*, August 2007

[22] Image used in Frank, A. Personal Energy Efficiency Rewards – A Behavioral Cocktail. Efficiency 2.0 http://www.stanford.edu/group/peec/cgi-bin/docs/events/2010/becc/presentations/4E_AndyFrank.pdf citing McCalley and Midden (2002)

Figure 15[16]



Some research, including Ipsos MORI's recent work for Consumer Focus[23], suggests that **historical comparisons** may be perceived more credibly by householders. Providing participants with information about their own consumption from the same period a year earlier could be more effective in encouraging behaviour change than normative comparisons with other households which can be dismissed due to perceptions of a lack of comparability due to differences in lifestyle and so on. However, the Centre for Sustainable Energy highlight that historic comparisons can only be effective in reducing energy use as long as households energy consumption is increasing year on year. In addition, the social pressure exerted by comparison information could be more likely to encourage behavioural change. Indeed one study[24] showed that participants provided with comparative data saved more energy over the course of the research than participants provided with their own historic comparisons. Bills which provide both historic and comparison information are likely to be the most effective[25].

[23] Ipsos MORI (2010). Consumer Views of Energy Bills. Qualitative research conducted for Consumer Focus
[24] Siero et al, "Changing Organizational Energy Consumption Behaviour through Comparative Feedback", *Journal of Environmental Psychology*, 1996
[25] Staats et al, 'Effecting durable change', *Environment and Behaviour Journal*, 2004

3. Motivating message frames for encouraging environmental behaviour change

Overall, it appears that a combination of text, diagrams and tables are seen as more effective than single-format presentations. In addition the combination of feedback information with target-setting is likely to be more encouraging given people have different barriers to change which can be overcome in different ways[26]. While charts are preferable, text labels are needed to assist understanding (Ofgem 2003). Therefore it is important for our research to consider the text or messages which accompany the consumption data. It is important to consider the content, language and tone of this information.

The Consumer Focus research recently conducted by Ipsos MORI provided some useful findings around terminology. For instance, the term 'neighbours' was found to be almost universally disliked by UK participants in the context of comparing individual household energy consumption. The term 'neighbours', whilst effective in a US-context, was taken very literally by members of the UK general public to mean people living in next door properties. This led to comparative information lacking credibility for these householders as they perceived there to be important differences between the lifestyles of their own household and that of their neighbours which would account for differences in energy use (for instance different working arrangements, appliances etc). Householders were more positive towards comparisons which were presented within the terminology of 'average energy consumption for similar premises'.

Ipsos MORI have conducted message testing to understand how to increase the salience of environmental issues among the general public. This research tested messages spanning a range of style, tone and language. The research puts forward a number of suggestions for effective communication which are outlined below.

- It is important to **offer a clear solution**. Information included alongside the benchmarks must therefore not simply tell a consumer that they are over-consuming but must offer a solution to this. A powerful formula for messages may be to outline the problem, then to describe the negative impacts and to follow this up with a solution.

- Need to **avoid suggesting blame or significant responsibility**. There is a lot of resistance to messages that suggest individuals are to blame for problems relating to the environment or climate change. The majority do not respond well to suggestions that they have a significant responsibility for dealing with the consequences. This is often the case as many people feel they are already 'doing their bit' and that other people could bear more responsibility.

- **Inclusive language** is well received. People seem to respond well to messages that propose an inclusive approach and collective working together towards a solution, rather than suggesting individuals ('you') are responsible for sorting out the problem. This suggests messages accompanying the benchmarks need to talk collectively about householders and the actions they can take rather than the 'Smith's' family on their own for example.

- A **pragmatic and authoritative tone** tends to be best received. A pragmatic tone is preferable to preaching, scare-mongering and hyperbole and is considered more trustworthy. Adopting a scare-mongering tone can lead people to dismiss the credibility of the message. Messages should be clear and concise in their language and tone in order to convey honesty and pragmatism.

- People tend to be less receptive to messages that suggest a possibility rather than a **certainty**. While this was tested in relation to environmental impacts from climate change, such as the likelihood of flooding, this recommendation can be transferred to the communication of benchmark information. It will be important to provide as much certainty as possible on consumer bills about comparator groups' energy use. The inclusion of simple information which validates the accuracy and robustness of the calculations may help here.

[26] Abrahamse, W. Energy Conservation through Behavioural Changes. New Zealand Centre for Sustainable Cities, University of Otago, Wellington.

- Make messages **directly relevant to the consumer**, suggesting the possibility that they could be affected personally in the near future. This can be achieved by focussing predominantly on the human impacts of environmental issues, by emphasising the impacts felt at a local, or at least UK level and, where relevant by communicating that impacts will be felt within people's lifetimes. The Centre for Sustainable Energy report (Ofgem 2003) concurs that "participants need to be given not just relevant, engaging feedback on their bills but a motivating justification to act".

Research among UK participants suggests that energy saving tips contained within bills would be favourably received (Ofgem 2004). There is some scepticism about the motivations of energy companies promoting energy saving and their credibility and trustworthiness to give impartial advice. For this reason there have been mixed opinions among participants on a statement such as the one below appearing on a bill. It will be useful for DECC's research to test the reactions of UK participants to this sort of information accompanying energy consumption benchmark data.

We have targets to save you energy.

We've a wide range of offers to help you – are you getting your share?

Call us FREE on 0800 111 111

Implications for research design and focus

This review of the existing literature presents a range of implications for the focus and design of the research currently being conducted for DECC.

- There is a need to test the most commonly understood form for conveying numeric data (e.g. percentages, fractions, textual description).

- Some groups of the public are likely to be less able than others to interpret numeric data. Recruitment of participants for the initial group discussions should therefore ensure factors which are related to this are incorporated (particularly age and social grade).

- The research with participants needs to explore trust in energy suppliers as the provider of comparative information. The research should explore the steps which can be taken, perhaps through appropriate messaging and language, to overcome barriers related to lack of trust.

- Some groups of the public are less likely to trust data which is provided to them. Recruitment of participants for the in-depth in-home interviews may wish to focus on these groups of participants (older people, women, those in lower social grades and with lower levels of education).

- Comparative data is most likely to appear credible and be motivating to participants if it is as tailored and specific to householders' own personal circumstances (i.e. property type and lifestyle) as possible. This is due to participants' tendency to rely on self-validation as a method of determining trust in data.

- A range of graphics for presenting comparative data have been tested in previous research studies. Some of these designs have received negative feedback from participants and have been inaccurately interpreted (e.g. the bell curve shown in Figure 3). It may be wise to discount this

design from the current research for DECC. However, there are many other designs with limited testing or with inconclusive results. It would be worth testing these designs in the context of UK participants. Our suggestions for stimulus to use in the group discussions are included in the Appendices.

- Goal-setting has been found to be effective in encouraging behaviour change among participants. Although not a specific objective for this research it may be worth testing this concept with participants.

- It will be important to test the benchmarks with householders who have a range of energy consumption behaviours. This will ensure we test the effectiveness of the benchmarks for low-consuming householders who in other studies have been dissuaded to change their behaviours.

- In addition to testing the graphics used to present benchmark data it will be important to test the additional information which may accompany this data. This may be technical information to reassure participants of the validity of the data and also information about how to change consumption behaviours. The style, tone and language of these messages will be important in determining consumer reactions to them.

Appendix C: Presenting benchmark data

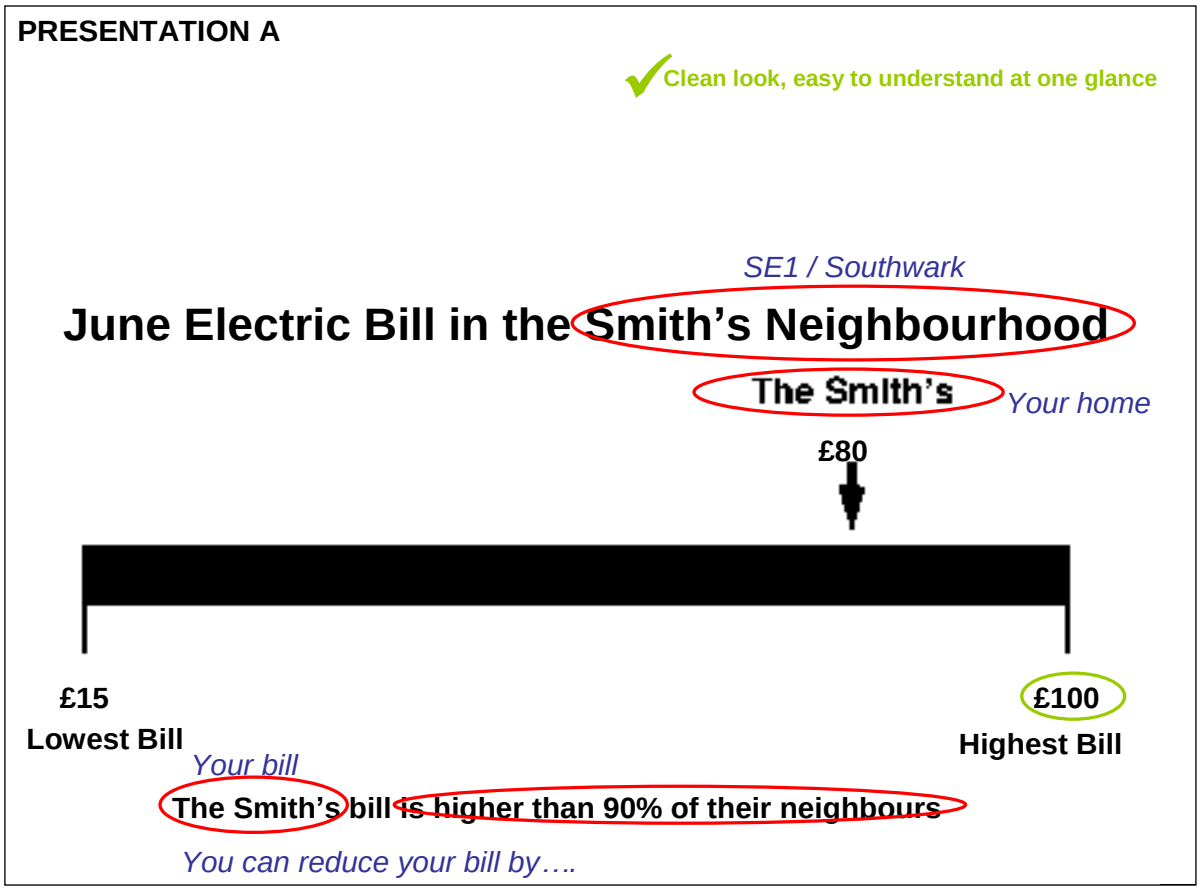
A summary of findings from the group discussions

During the six group discussions the following presentation options were tested with participants. This shortlist of options was informed by the previous research reviewed.. A summary of the reactions captured for each option is given below.

Green text indicates positive elements of each design according to participants.

Red text indicates negative elements of each design according to participants

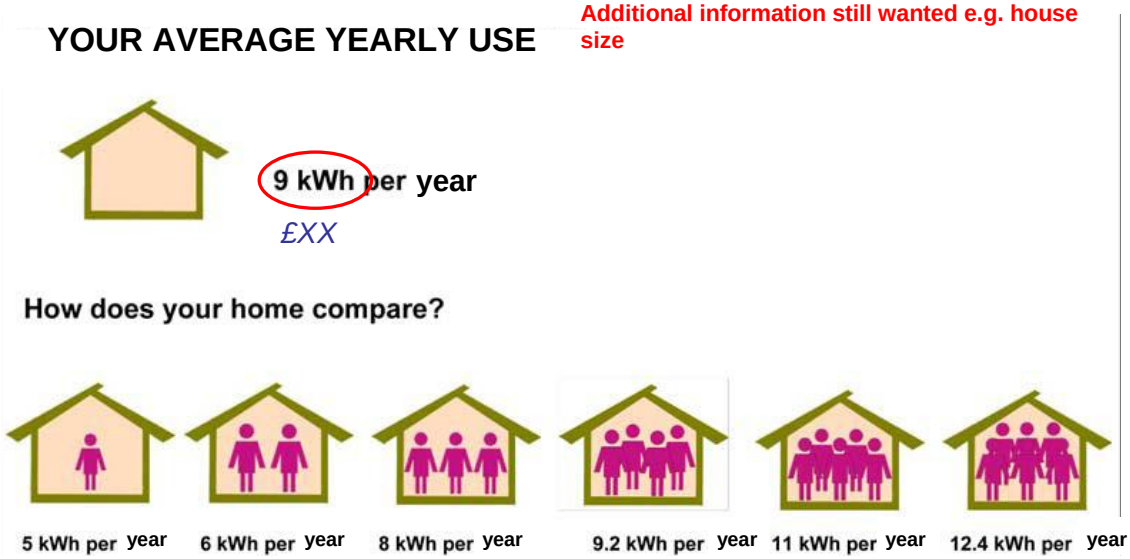
Blue text indicates suggested improvements to each design according to participants



PRESENTATION B

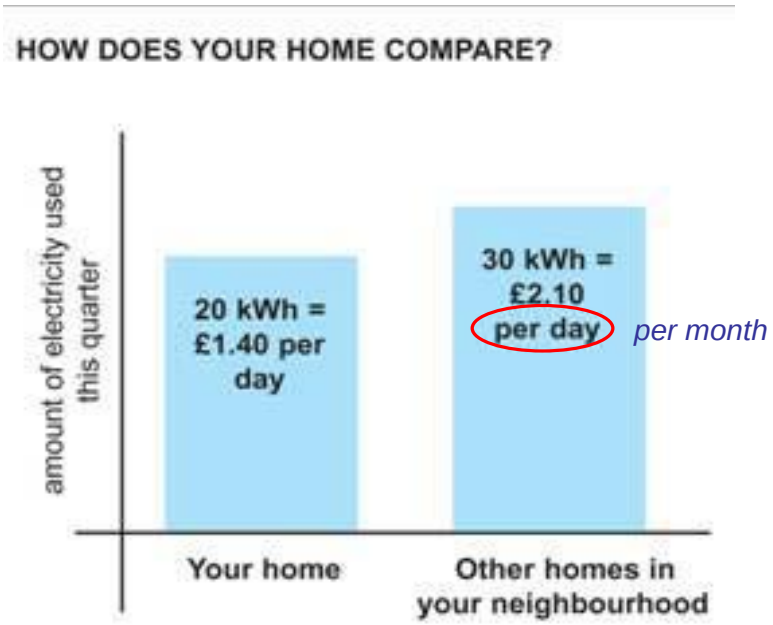
✓ -Simple, use of colour
- Provides more detail about specifics of property

✗ Open to misinterpretation
Additional information still wanted e.g. house size



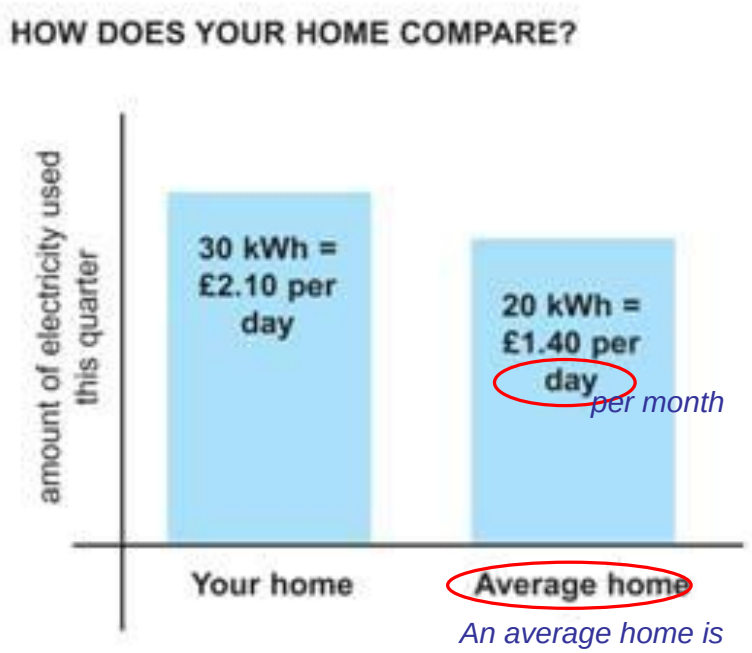
PRESENTATION C

✓ - Bar chart format familiar and simple



PRESENTATION D

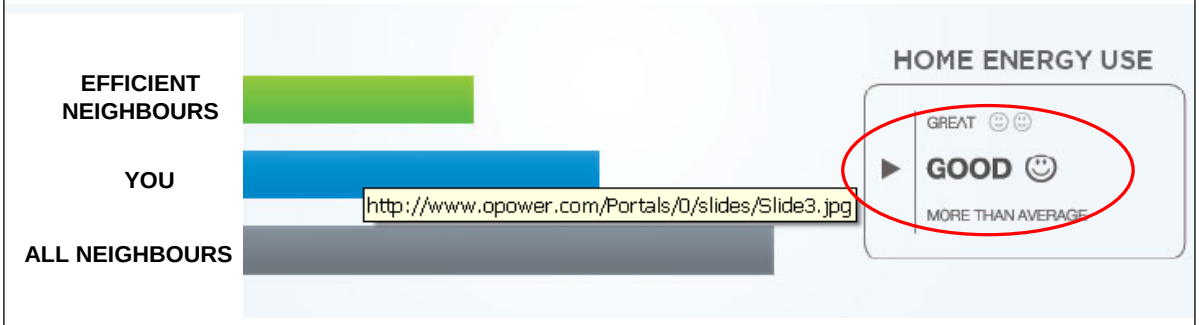
✓ - Bar chart format familiar and simple



An average home is considered to be….

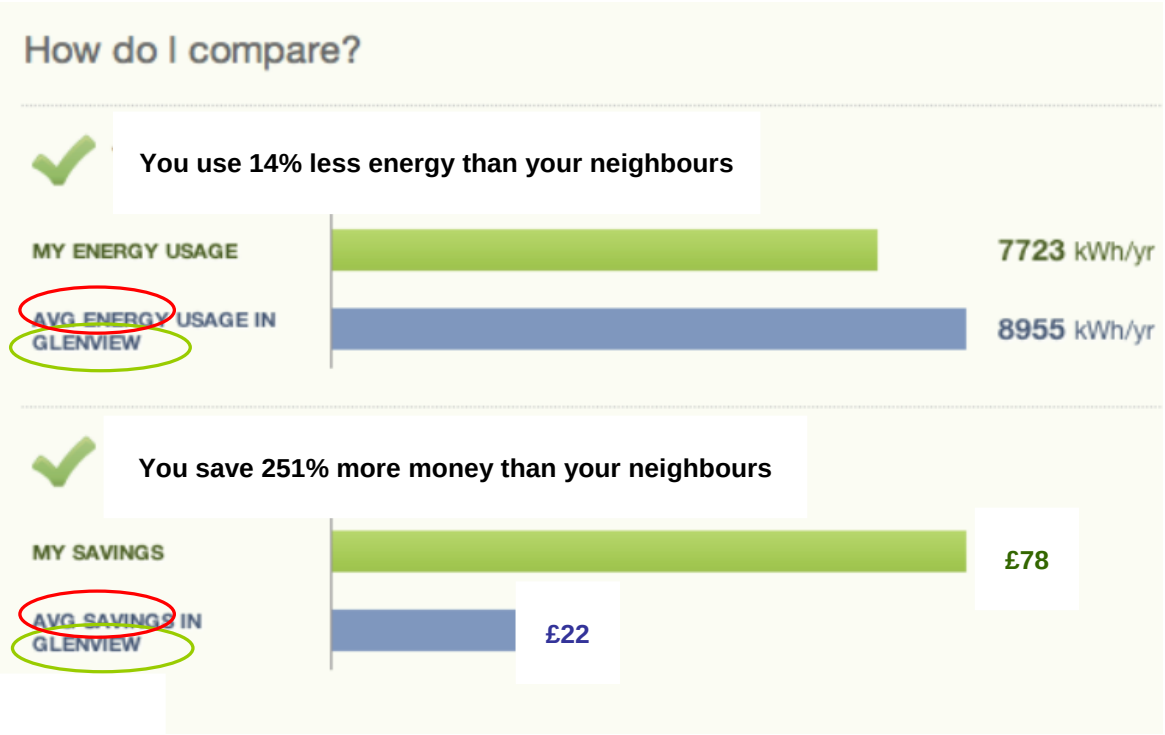
PRESENTATION E

✘ - Patronising
- Not clear how the two graphics relate to one another



PRESENTATION F

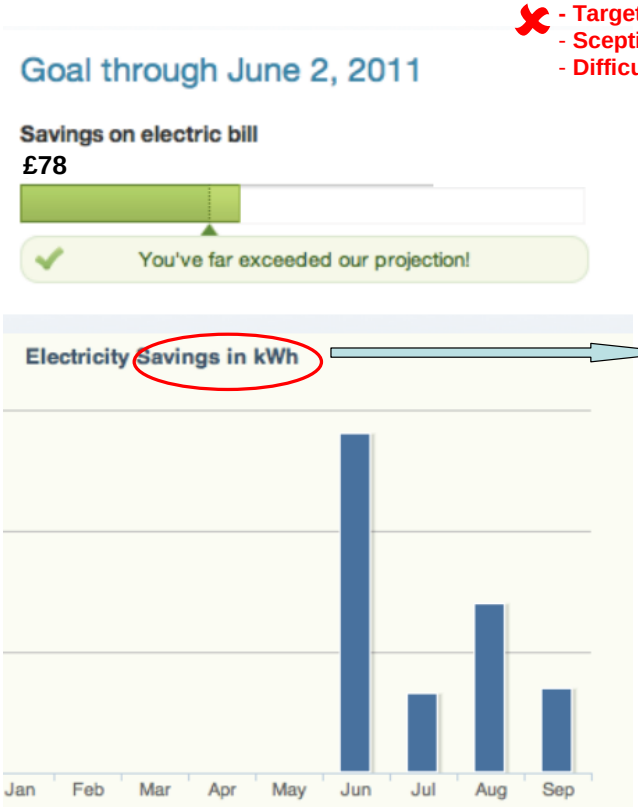
✗ Horizontal bars liked less than vertical bars



PRESENTATION G

✓ Focus on savings

✗
- Targets are intrusive
- Scepticism around motivations
- Difficult to understand

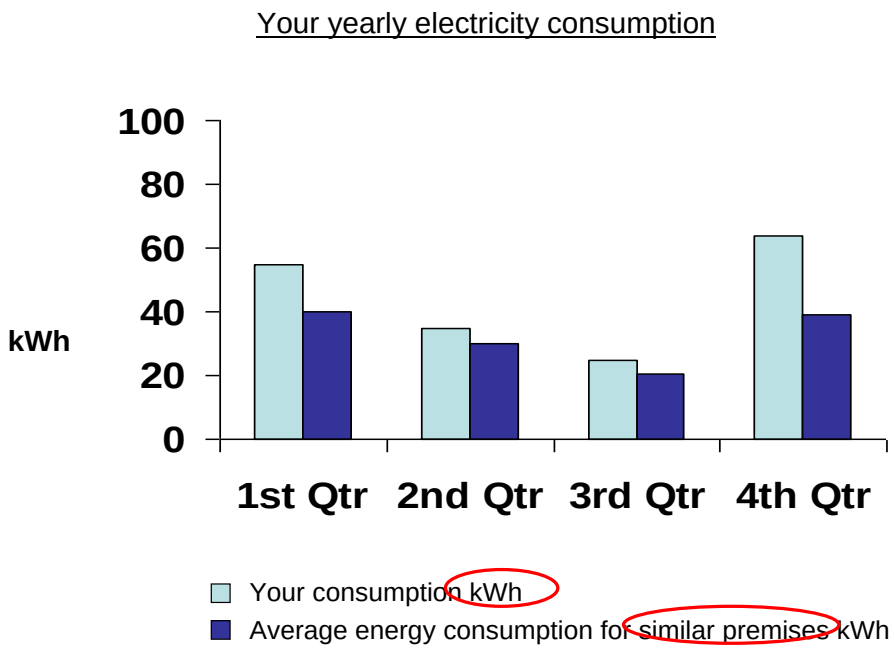


Running your washing machine at 30º would save you XXkwH…

PRESENTATION J

✓ Clear, easy to understand

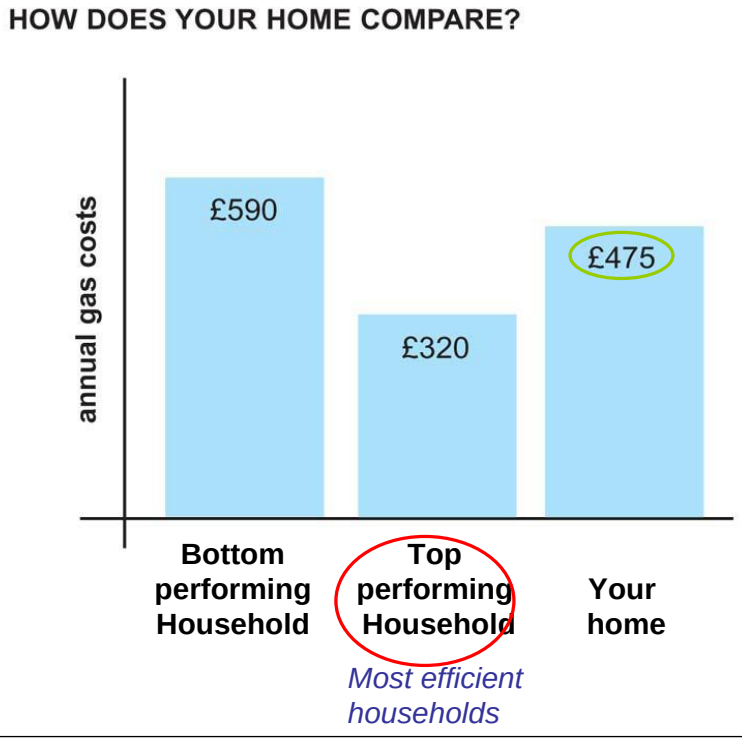
✗ Potentially too similar to current graphics included on energy bills and so may be overlooked



PRESENTATION K

✓ Shows a range of costs rather than one average – liked by some younger people

✗ Terminology not liked by some



Appendix D: Producing benchmark data

Statistically, the overall aim of this exercise was to produce credible energy consumption benchmarks for a range of consumers, including those who are off the gas grid and who use electricity to heat their homes.

This appendix provides further information about the statistical analysis conducted as part of this research and includes an explanation as to why the median has been put forward as the recommended benchmark; the methodology used for calculating the energy consumption benchmarks; and the methodology developed for predicting expected consumption values based on the characteristics of a household and the surrounding geographical area (on Lower Level Super Output Areas, LLSOA, in England and Wales and at Intermediate Geography Zones, IGZ, in Scotland).

Summary

Key points

- Results from the qualitative research indicated that an average[27] measure of energy consumption from the local area was the most appropriate benchmark for participants. In light of this and given the distribution (positive / right skewed) of the energy consumption data, Ipsos MORI calculated an average energy consumption figure based on the median value within each LLSOA[28] and IGZ[29]. A statistical analysis on why the median was preferred to other measures of the average are discussed later in the Methodology section.

- Energy consumption benchmarks, based on the median energy consumption statistic, have been calculated for all LLSOAs and IGZs in Great Britain. In total there are 34,378 LLSOAs in England and Wales and 6,505 IGZs in Scotland.

- Median energy consumption values have been calculated for both Gas and Electricity separately. For electricity consumption, benchmarks have been produced for ordinary domestic (profile 1), Economy 7[30] domestic (profile 2) and for profile 1 and profile 2 combined.

- A series of regression models, split by fuel type and by country which are detailed in the Final Models section, have been provided to enable specific targeting of LLSOAs/IGZs which are over consuming based on their respective characteristics. These models produce an expected level of energy consumption within the LLSOA to compare to the actual consumption within the LLSOA. Benchmarks were produced for gas and electricity (profile 1 and profile 1/2 combined only, not profile 2).

[27] Average and percentile benchmarks were tested with participants but the latter were misinterpreted as average values. The results from the qualitative research therefore indicate that an average measure of energy consumption was the most appropriate benchmark for participants.

[28] Lower Layer Super Output Areas (LLSOAs) are a statistical geography developed for the 2001 census by the ONS. LLSOAs were designed to have similar population sizes (circa 1,500 household residents) and to be as socially homogenous as possible (based on tenure of household and dwelling type). For more information http://www.neighbourhood.statistics.gov.uk/dissemination/Info.do;jessionid=ac1f930b30d5b8b58ac14f1547c68128a8461146f041?m=0&s=1307354828949&enc=1&page=userguide/detailedguidance/casestudies/geography/case-studies-geography.htm&nsjs=true&nsck=true&nssvg=false&nswid=1497

[29] The intermediate geography was designed to meet constraints on population thresholds (2,500 – 6,000 household residents), to nest into local authorities and to be built up from data zones. The aim was also to build intermediate zones by grouping together data zones with similar social characteristics, to have a fairly compact shape, and to take account of physical boundaries. For more information: http://www.scotland.gov.uk/Publications/2005/02/20732/53083.

[30] Economy 7 is a domestic off-peak based tariff.

Output

Ipsos MORI have provided two different types of benchmark:

1) The first type is based on the median for each individual LLSOA/IGZ for gas and electricity (profile 1, profile 2 and profile 1 and 2 combined) separately calculated directly from the cleansed data.

   This allows for each meter point within a LLSOA/IGZ to be compared to the median of that respective LLSOA/IGZ, enabling meter points over consuming in comparison to the median to be targeted only. This is reliant on the homogeneity of the LLSOA/IGZ.

2) The second type of benchmark takes into account the household and residential characteristics of the LLSOA/IGZ. See the 'final models' section for the chosen variables. By looking at the characteristics of the LLSOA/IGZ it can be identified whether or not the LLSOA/IGZ is over consuming in comparison to what you would expect the area to be consuming considering its characteristics. From this model separate benchmarks for gas and electricity (profile 1 and profile 1/2 combined, not profile 2) have been produced.

   Comparing the actual energy consumed against the expected median amount of energy consumed allows one to identify and target over consuming LLSOAs/IGZs. Models were run separately for Gas and Electricity.

For electricity, benchmarks were produced for profile 1 meters, profile 2 meters and profile 1 and 2 meter combined. The set for profile 1 and 2 electricity consumption combined allow the calculation of the median amount of electricity consumption that represented all households in the LLSOA/IGZ rather than just those on profile 1 or profile 2.

However due to the high penetration of profile 1 participants in most LLSOAs/IGZs a model was also run based on the median consumption of profile 1 households in an LLSOA/IGZ. For both Gas and profile 1 electricity, no expected median value was calculated for LLSOAs/IGZs below a certain threshold[31]. Due to a lack of household data for profile 2 households only, the model was not run for this profile.

By comparing the actual consumption of a household with the median consumption of all households in the same LLSOA/IGZ it is possible to identify if the household is consuming more or less than the average (median). This is of most use when all households in the LLSOA/IGZ have very similar characteristics.

As well as an **actual** measure of energy consumption an **expected** level of energy consumption was calculated for each LLSOA/IGZ. This, the second type of benchmark, is produced from the models which use Census and other official data sources on the characteristics of the household/resident population that impact on household energy consumption. A forward stepwise[32] selection method using linear regression was used to identify those key characteristics that had the strongest relationship with energy consumption.

[31] The percentage of households off the gas grid in each LLSOA/IGZ was calculated by dividing the total number of Gas meters in an LLSOA/IGZ by the total number of dwellings. Any LLSOAs/IGZs with a value of 20% or more were excluded.

[32] Forward selection is one of the approaches used within the linear regression technique to determine the predictors within the regression model. It is an iterative process that commences with a null model; that is a model containing only a constant term and no predictors. At each iteration, the model calculates the coefficients of all the candidate variables (variables tested for inclusion into the model) that are not already selected in the model and the variable that is most significant is added. This is determined by the variables' respective p-values, which test the statistical significance of the effect of the variable on the outcome. The variable with the lowest p-value is selected. Further iterations are run until there are no more variables outside the model that have a p-value lower than the chosen level of significance (usually, and in this case, 0.05).

The final characteristics used in each model can be found in a later section of this appendix, along with information on how well these characteristics can explain the LLSOA/IGZ level variation in consumption.

Calculation of a Benchmark statistic

DECC provided Ipsos MORI with meter point level annual gas and electricity consumption data for 2008. Using these datasets Ipsos MORI were tasked with providing a benchmark statistic for all LLSOAs and IGZs in Great Britain. The qualitative research that had taken place prior to calculating the benchmark statistics indicated that an **average** measure of energy consumption was more appropriate than percentiles as a local area level benchmark for participants. Thus there were 3 options open to us; the arithmetic mean, median or mode.

Previous LLSOA level energy consumption statistics published by the Office of National statistics[33] had used the mean. However the mean is likely to be influenced by outliers as it uses all of the meter point consumption data. In comparison, the median is more robust to a small number of very large outliers and is therefore more likely to provide a more accurate estimate of the typical amount of energy consumed. The mode takes the most frequent value, which whilst useful for categorical data is less useful in our case, as the data tends to follow an interval scale with few meter points having exactly the same value, especially within the same LLSOA/IGZ.

An inspection of the Gas and Electricity (profile 1 and 2) consumption distributions in charts 1 to 3 highlight a number of issues with the use of a mean or a mode as the measure of average consumption. All three distributions in charts 1 and 2 show a small number of very frequent consumption values, often referred to as spikes. If we were to use the mode, then these spike values (coloured in red) are likely to represent the average in a large number of the LLSOAs/IGZs. These spikes are not considered to represent actual annual consumption, rather they are industry default values used by the gas/electricity suppliers when they do not have a valid meter reading. Removing these spikes, the distributions are fairly smooth with no definitive peak.

This type of distribution does not lend itself to the use of a modal value as we are unlikely to see a high number of exactly the same meter point consumption values in an LLSOA/IGZ, thus a mode would not be a very reliable measure for the benchmark statistic.

Using the arithmetic mean given that the distributions are positively skewed will lead to mean values that are higher than the majority of the meter point consumption values within an LLSOA/IGZ and therefore not represent the typical level of energy consumed. Table 1 shows the percentage of LLSOAs/IGZs where the value for the mean is higher than the values for the median (50th percentile), 60th percentile and 70th percentile. In all three cases, the mean provides a higher value than the median across the majority of the LLSOAs/IGZs. In a large number of LLSOAs/IGZs the mean is even higher than the 60th percentile, particularly for electricity consumption. This is expected given the extended positive tail in the electricity consumption distributions. This is illustrated clearly in chart 3, which shows the distribution of profile 1 electricity consumption for one English LLSOA. As we can see the distribution is very positively skewed. The mean for this LLSOA is over 3,000 kWh, which is higher than the 60th percentile (2,643 kWh).

In light of these points we have chosen the median as the benchmark statistic to represent the average energy consumed in an LLSOA/IGZ. The median will ensure that 50% of households are categorised as over consuming participants and 50% under consuming participants in each LLSOA/IGZ. It is robust to positively skewed distributions, with a small number of very large outliers and is a suitable statistic to use for this type of data (interval scale). Median energy consumption statistics at the LLSOA/IGZ level have been calculated for both Gas and Electricity separately. Electricity has been further split into ordinary domestic (profile 1) and Economy 7 domestic (profile 2) consumption. All statistics are calculated based on the cleaned datasets.

[33] http://www.neighbourhood.statistics.gov.uk/dissemination/MetadataDownloadPDF.do?downloadId=26286

Table 1 - Percentage of LLSOAs/IGZs where mean value is higher than 50th, 60th and 70th percentile

Energy Type	% LLSOAs/IGZs where Mean > 50th percentile	% LLSOAs/IGZs where Mean > 60th percentile	% LLSOAs/IGZs where Mean > 70th percentile
Gas	97%	12%	0.2%
profile 1 Electricity	100%	63%	1%
profile 2 Electricity	95%	55%	6%

Chart 1 – Annual gas consumption (kWh) distribution

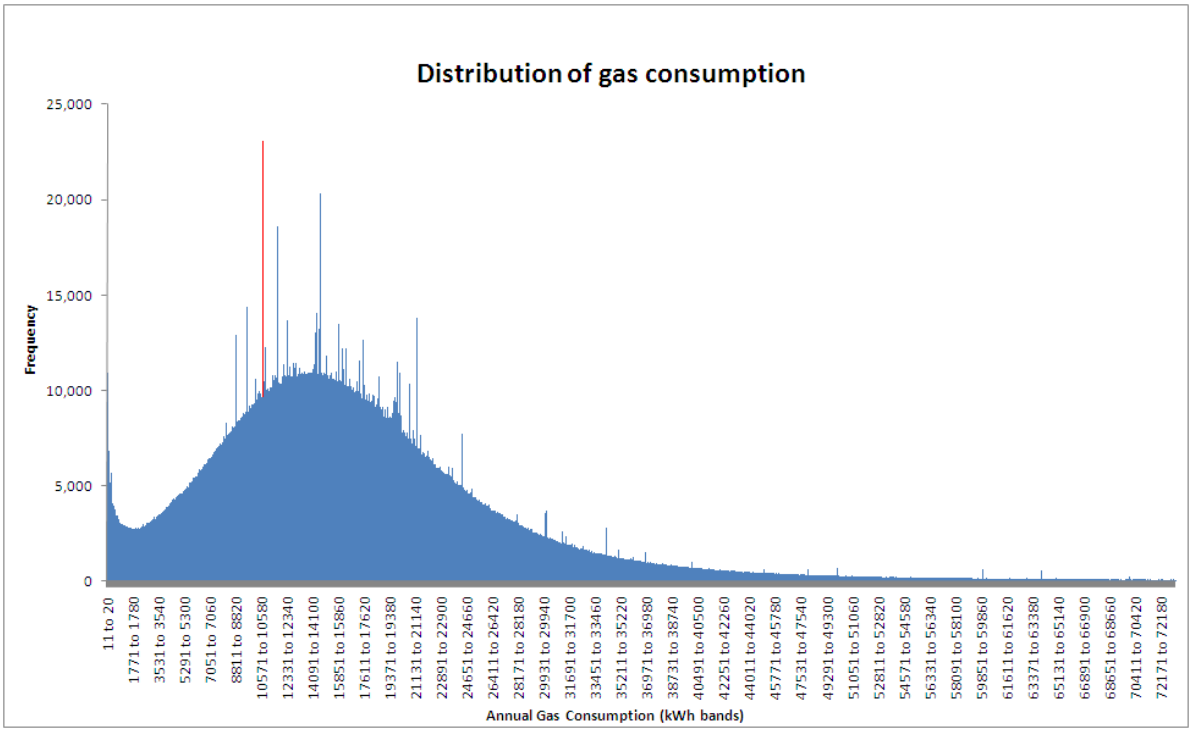


Chart 2 - Annual electricity consumption (kWh) distribution for profile 1 and profile 2 consumers

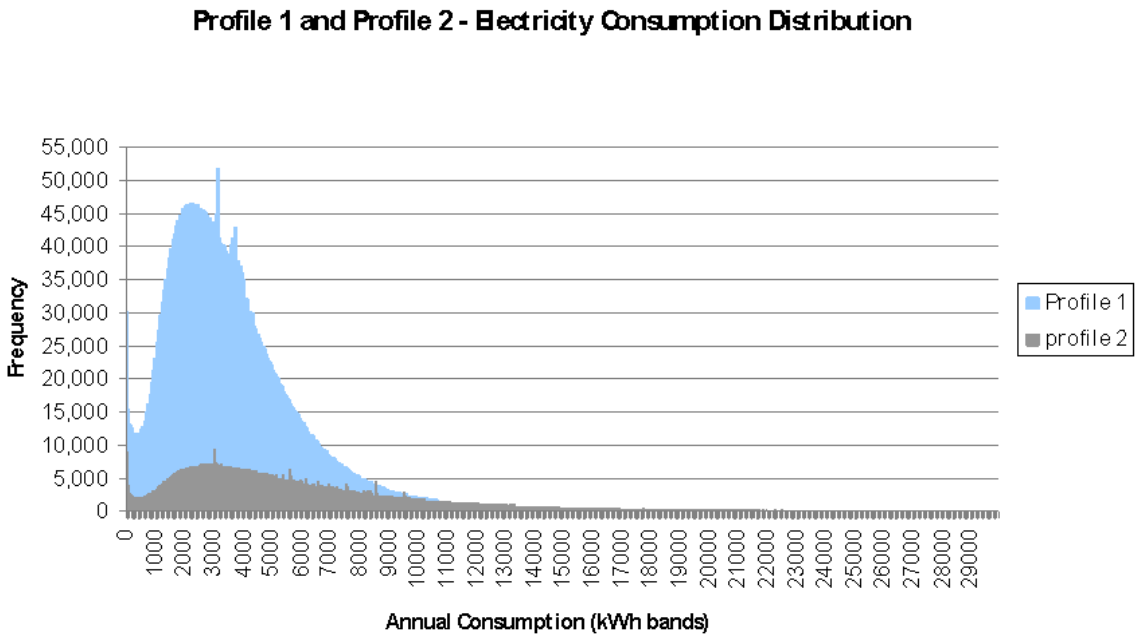
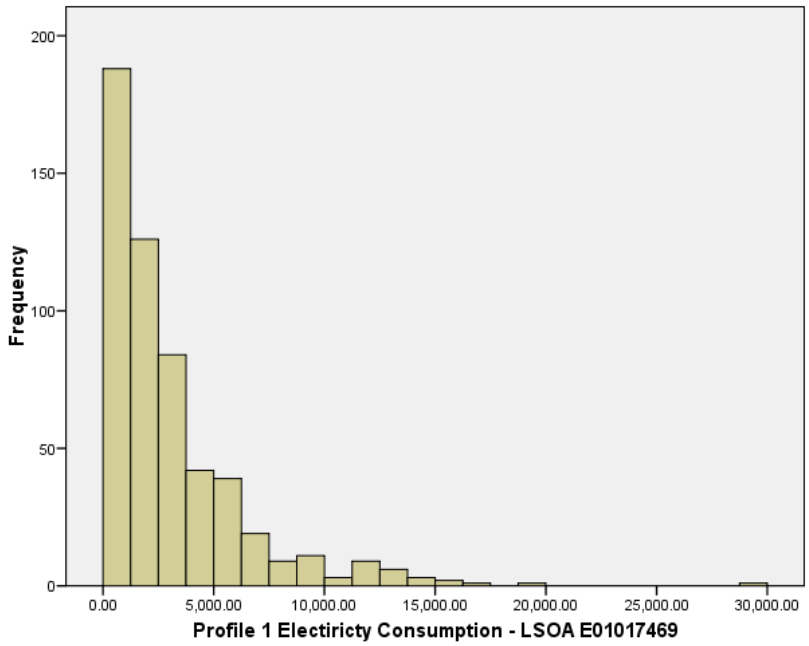


Chart 3 - Distribution of profile 1 electricity consumption for one LLSOA



The next section outlines in detail the steps we took to clean the datasets before calculating these local level energy consumption statistics.

Cleaning the meter point consumption data

The median energy consumption statistic for each LLSOA/IGZ was calculated from the meter point level Gas and Electricity datasets provided to Ipsos MORI by DECC, but prior to calculating the median values, it was decided to remove any negative consumption values, values above a certain ceiling threshold and values with relatively high frequencies from the raw data. The decision to exclude these values was to increase the reliability of the benchmarks produced.

The following section notes the stages undertaken to further clean the data and the reasoning behind these stages. During the rest of this report the data that were removed during the cleaning stage will be referred to as outliers. For both the gas and electricity data these outliers were removed from the data prior to estimating the LLSOA/IGZ consumption statistics.

GAS consumption data

For the **gas data** outliers were defined based on the following criteria:

1. Any reading below zero or missing
2. Any reading equal to zero
3. Any reading less than 50 kWh
4. Any reading greater than or equal to 73,200 kWh
5. Any reading that appears 1.5 times more frequently than readings of a similar value

Table 2 - Meter point counts for each criterion

Criteria	Count	% of all meter points
1. < zero/missing	143	0.001%
2. zero	35	0.000%
3. > zero and < 50	315,894	1.415%
4. >= 73,200 kWh	260	0.001%
5. Imputed meter points	343,866	1.540%
Total	660,198	2.957%

The reasoning behind each criterion is as follows:

Criteria 1: From year-to-year some meter readings supplied by data aggregators change from an actual reading to estimated and vice-versa, which can cause extreme and negative values to be created when an estimate is corrected. Given that we are interested in actual consumption estimates for 2008 these values were excluded. There were no negative values in the gas dataset, however 143 meter points had missing information.

Criteria 2: The decision to exclude zero counts was taken on the assumption that the household is unoccupied.

Criteria 3: Meter points above zero but under 50 kWh were excluded on the basis that this was an extremely low level of consumption and therefore not likely to representative of an occupied household.

Criteria 4: Values of 73,200 kWh per annum or above were excluded as it is the general approach of the gas industry to allocate these to the non-domestic sector.

Criteria 5: The final criterion was taken based on a closer examination of the raw data. When we looked at the domestic gas consumption distribution we found that there were a number of spikes. These spikes are the gas industry default values used by the gas suppliers when they do not have a valid meter reading. These spike values were excluded from the calculation of the consumption statistics, as they may not represent the consumption of that particular meter point.

In our opinion removing the spikes completely will provide the most reliable benchmark estimate. The smoothed value assigned to the meter point is not a reliable estimate of the actual energy consumed by that household. Removing the spikes and calculating the median, mean and percentiles from the remaining meter point values will stop these spike values influencing the LLSOA/IGZ statistics. If these meter points with supplier default values are missing completely at random then excluding them from the calculation of the LLSOA/IGZ statistics will have no biasing effect on the estimates. By missing completely at random we can assume there is no systematic reason why a household with missing meter point data would, on average, be any different (e.g. more/less rooms in household) to a household with valid meter point data.

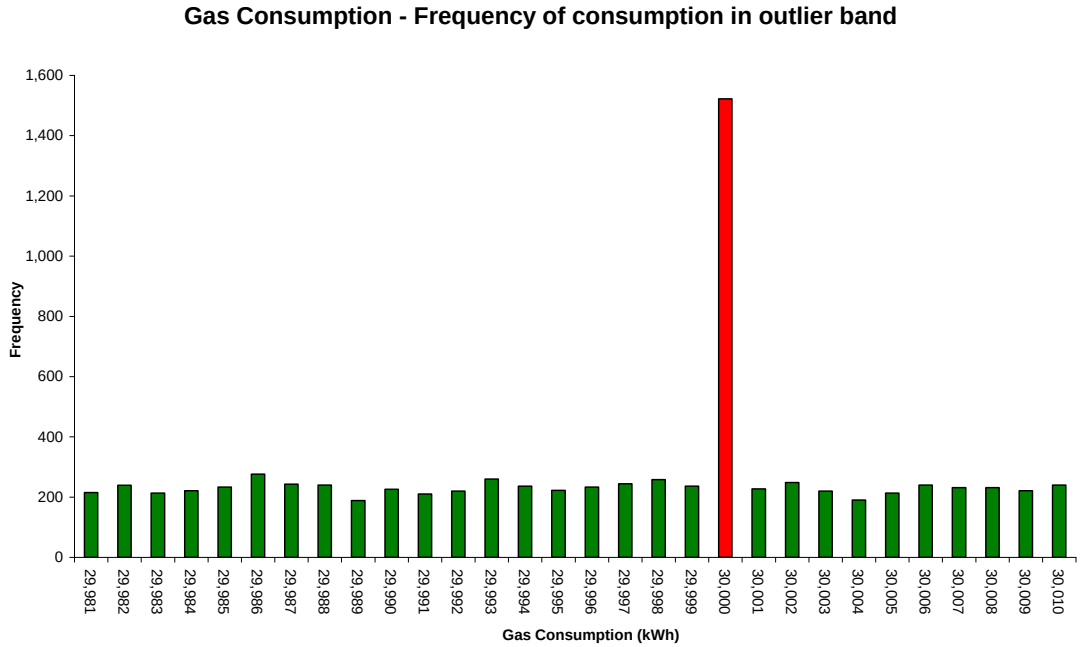
To identify the spikes in the gas data we took a very similar approach to other DECC analysis. The first step was to band the consumption data up into 10 kWh bands (e.g. 0 to 10 kWh, 11 to 20 kwh etc.). The next step was to count the number of individual meter points in each 10 kWh band. 10 kWh bands that had an unusually high number of meter points were identified. We looked at 5 threshold values to flag unusually high numbers. Our final choice of threshold value was 130%. Therefore any 10 kWh band that contained more than 1.3 times as many meter points in it as the 10 kWh bands either side of it were flagged as containing imputed consumption data, this amounted to 104 bands (circa 1.4% of all bands) that we needed to investigate further. This threshold value was slightly higher than that used by DECC, who used a threshold value of 110%. Table 3 provides information on the count of bands with unusually high numbers at each of the 5 threshold values. Chart 1 shows the distribution of gas consumption data for each 10 kWh band. The spikes in Chart 1 relate to these outliers. A full list of these outlier values can be found in the appendix.

Table 3 – Number of bands exceeding threshold values

Criterion	Number of 10 kWh bands	% of meter points
> 110%	672	4.38
> 120%	246	3.34
> 130%	104	2.83
> 140%	55	2.28
> 150%	39	2.05

In the final step frequencies were run on the meter level data within each of the flagged 10 kWh bands to identify the outlier value(s). The outlier(s) is then removed from the gas consumption dataset before the consumption statistics are calculated. As an illustration Chart 4 provides the count of meter points for one of the 10 kWh bands identified as containing an outlier (29,991 kWh to 30,000 kWh) and the two bands either side. As we can see there are a very large number of meter points with the same value of 30,000 kWh per annum. Relative to consumption values above and below 30,000 this value is approximately 6 times as high, therefore these 1,500 meter points are removed from the dataset and excluded from the calculation of the area level consumption statistics.

Chart 4 – Frequency of meter point values for an outlying 10 kWh band (29,991 kWh to 30,000 kWh) compared to two adjacent bands



After removing the outliers based on the five criteria outlined above we checked to see if these outliers were well spread across the majority of LLSOAs/IGZs or were concentrated in just a few of them. Our hope was that they tended to fall across the majority of LLSOAs/IGZs thus ensuring that removing them would have minimal biasing effect on the LLSOA/IGZ level consumption statistics. Chart 5 shows the percentage of meter points excluded in each LLSOA/IGZ based on the 5 criteria. As we can see for the vast majority of LLSOAs/IGZs (92%) at least one meter point was excluded, which suggests the outliers are not specific to certain geographic areas. Also the majority of the LLSOAs/IGZs tended to have a very small percentage of their total number of meter points classified as outliers based on the above criteria, with 97% of LLSOAs/IGZs having less than 10% removed. In light of this information we can be very confident that the valid meter points in each LLSOA/IGZ are sufficient to provide reliable estimates for average gas consumption.

Chart 5 – Distribution of meter point exclusions

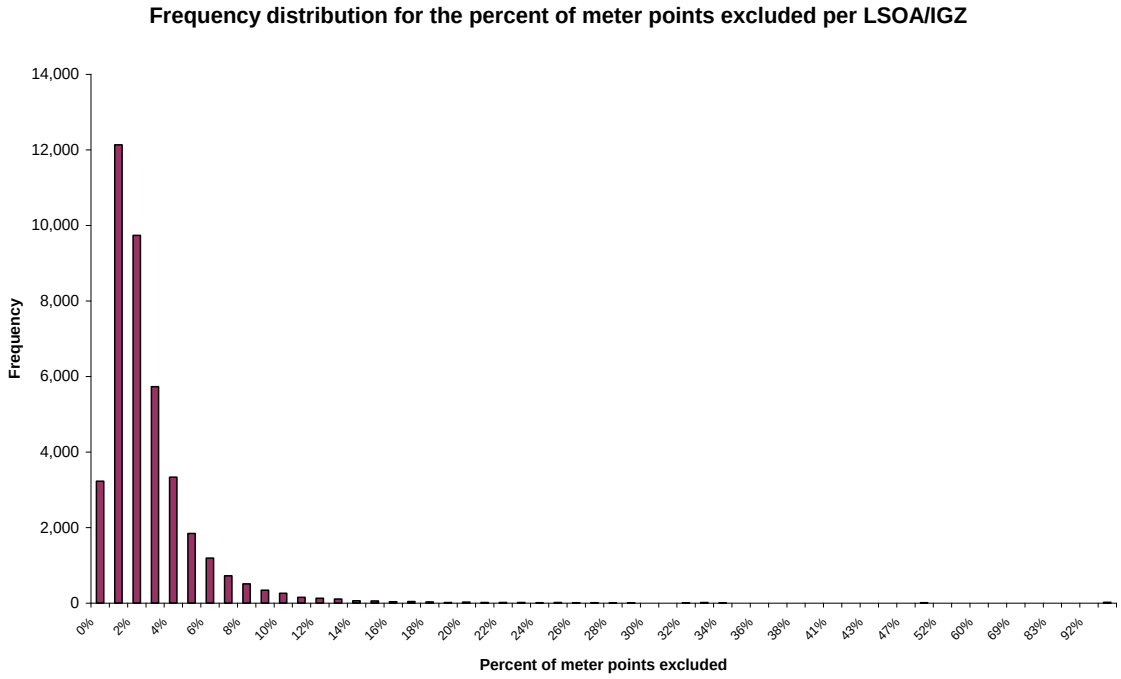
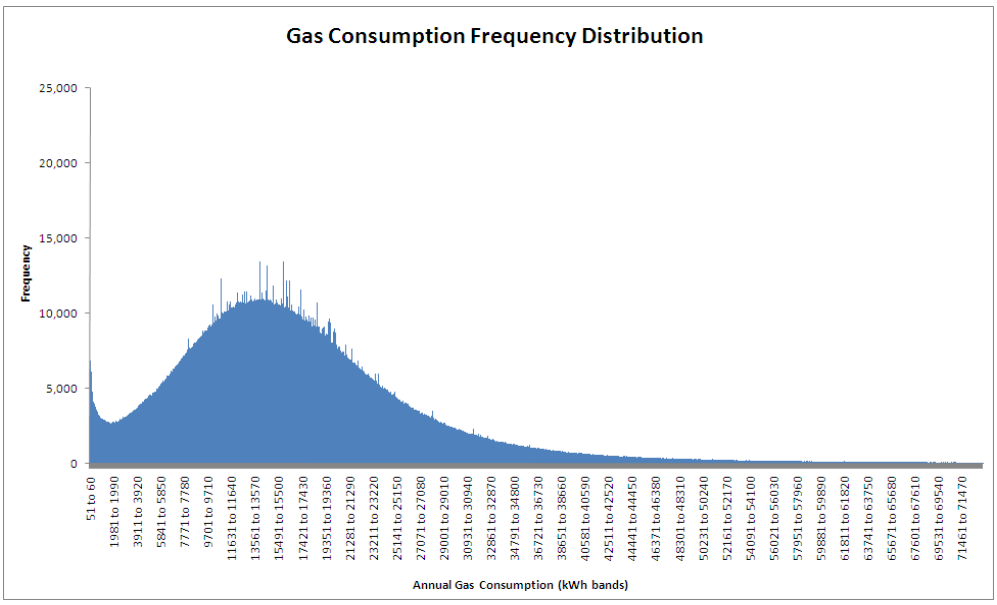


Chart 6 shows the Gas consumption distribution after removing the outliers. The meter points with values that were much more frequent than those of a similar value to them have almost been eradicated. There are a few spikes remaining, but these will have less influence on the LLSOA/IGZ consumption statistics as they are more in line with the expected frequency for that value. Removing these values is more likely to lead to the exclusion of valid consumption information, as the majority of the meter points with these values are going to be valid.

Chart 6 – Annual gas consumption (kWh) distribution



Information on the meter point level gas consumption values that were excluded based on criterion 5 can be found in the section called ‘additional information’ towards the end of appendix D.

Electricity Consumption Data

For the **electricity data** outliers were defined based on the following criteria

1. Any reading below zero/missing (negative)
2. Any reading equal to zero
3. Any reading greater than or equal to 100,000 kWh
4. Any reading that appears 1.1 times more frequently than readings of a similar value

Table 4 - Meter point counts for each criterion

Criteria	Profile 1 Count	Profile 2 Count	% of all meter points
1. < zero/missing	143,121	68,313	0.789%
2. zero	192,559	120,818	1.169%
3. >= 100,000 kWh	2,418	1,849	0.016%
4. Imputed meter points	42,438	9,608	0.194%
Total	380,536	200588	2.167%

The reasons for excluding electricity meter points based on the first two criteria are the same as those expressed in the gas section above.

In criterion 3 a maximum threshold of just under 100,000 kWh per annum was used for domestic electricity consumption to avoid the inclusion of small commercial/industrial businesses in the estimates, this was the same threshold used by DECC when publishing the 2008 electricity consumption estimates at the LLSOA/IGZ level[34]. We also ran a sensitivity check on the consumption statistics based on a maximum threshold of 50,000 kWh per annum. In terms of the mean and the median there was very little difference in the LLSOA/IGZ average consumption statistics when changing the ceiling threshold value. This is illustrated for the profile 1 data in Charts 7 and 8. The majority of LLSOAs/IGZs in Great Britain (over 30,000) showed very little change (less than 1%) in the mean, whilst for the median almost all LLSOA/IGZs (40,000) remained unchanged, this is to be expected, as the median is more robust to extreme outliers than the mean.

[34] http://www.neighbourhood.statistics.gov.uk/dissemination/MetadataDownloadPDF.do?downloadId=26286

Chart 7 – Results of sensitivity check (mean) on Profile 1 electricity consumption data

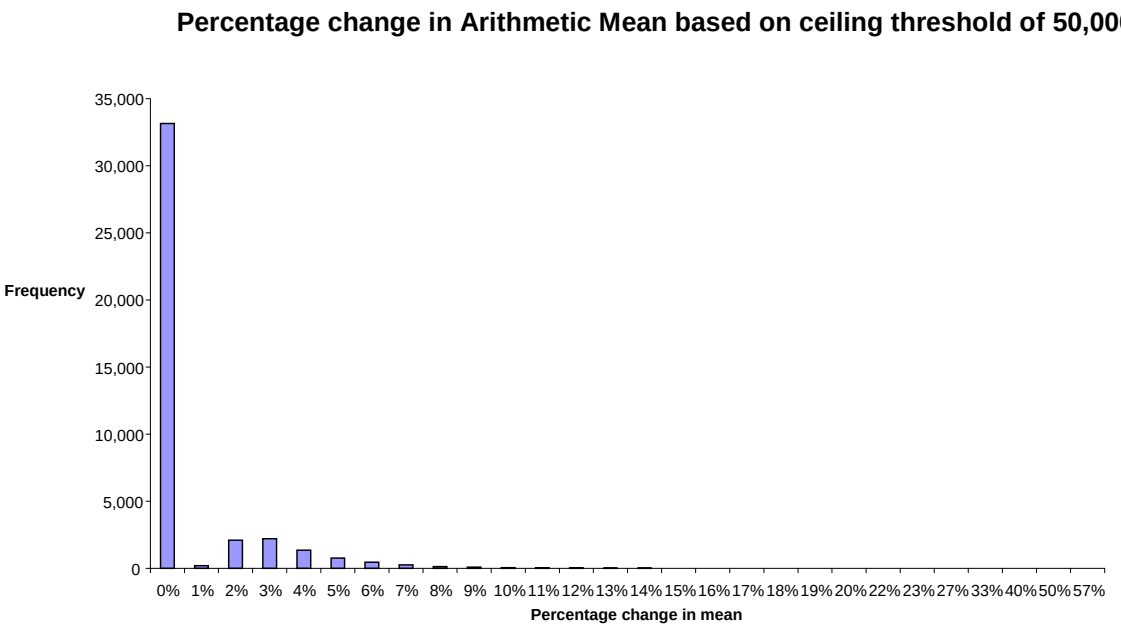
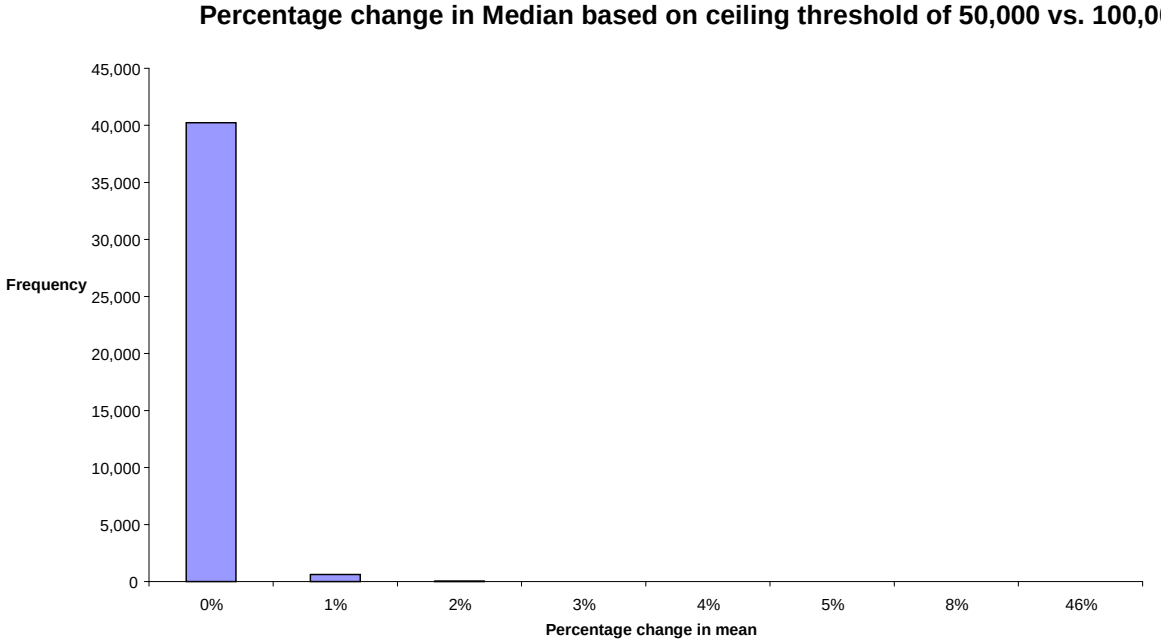


Chart 8 - Results of sensitivity check (median) on Profile 1 electricity consumption data

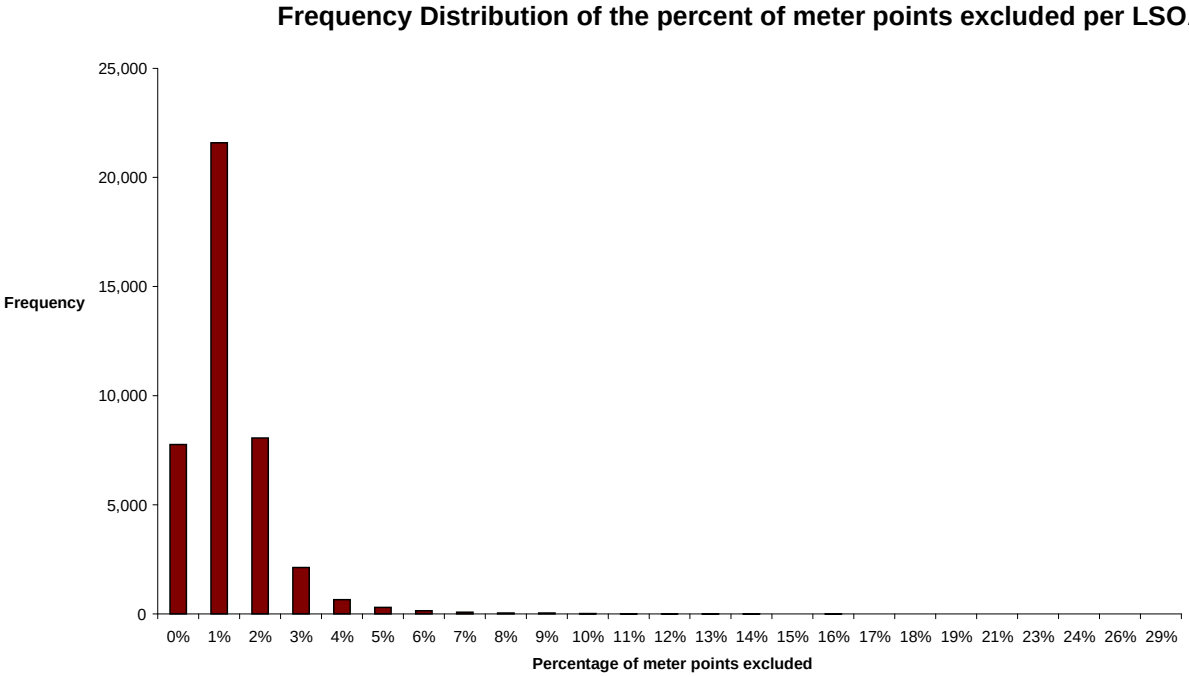


The profile 1 and 2 electricity distributions prior to the removal of the outliers can be seen in charts 2 and 3. In these two charts we can see that there are very few peaks in the profile 1 and 2 distributions relative to the gas consumption distribution in chart 1, suggesting the data tends to be cleaner with less imputed information. In total only 42,438 meter point values were removed from the profile 1 dataset and a further 41,175 from the profile 2 dataset.

Chart 9 shows the percentage of meter points excluded in each LLSOA/IGZ based on the 4 criteria listed in table 4. For the vast majority of LLSOAs/IGZs (81%) at least one meter point was excluded, which suggests the outliers are not specific to certain geographic areas. In total no more than 2% of meter points were removed from 92% (37,416) of all LLSOAs/IGZs in Great Britain. Therefore we can be very

confident that removing these outliers from the calculation of the consumption statistics will have minimal impact in terms of biasing the estimates.

Chart 9 – Number of meter point exclusions



Benchmark statistics based on the median energy consumption value in an LLSOA/IGZ (post cleaning the data) have been calculated for both gas and combined profile 1 and 2 electricity, as well as individual benchmarks for profile 1 only and profile 2 only. These have all been provided to DECC in excel. Additional summary statistics at the LLSOA/IGZ level have also been provided in the excel datasets including the mean, variance and percentiles.

Information on the meter point level electricity consumption values that were excluded based on criterion 4 can be found in the section called ‘additional information’ towards the end of appendix D.

Expected energy consumption estimates based on LLSOA/IGZ household/resident population characteristics

The aim of this analysis is to use household and residential characteristics collected at the LLSOA/IGZ level to predict expected median gas and electricity consumption in each LLSOA/IGZ in Great Britain. By taking into account the relationship between key household and residential characteristics of an LLSOA/IGZ with the median energy consumption of the LLSOA/IGZ we can provide DECC with an expected median amount of energy consumption. The actual median energy (gas and electricity) consumed will then be compared to this predicted median value to identify LLSOA/IGZ’s where median energy consumption is higher than expected.

All the data used to define the household/residential characteristics of an LLSOA/IGZ have been sourced from either the Neighbourhood Statistics website (NESS) or the Scottish Executive website and are therefore already in the public domain and freely available.

Table 5 – Variable collected for predictive model

Table	Title	Notes
UV 56	Accommodation type – household spaces	Detached, semi-detached, terraced, flat
UV 57	Number of rooms	Excluding bathroom, toilet, halls or landings
UV 51	Number of people living in households	Includes all people living at the same address who share housekeeping
UV 59	Occupancy rating	Measure of under occupancy and over crowding
UV 58	Person per room - households	Number of people living at same address who share housekeeping divided by the number of rooms in household.
UV 63	Tenure - households	Owned, Social rented, Private rented etc.
IMD	Indices of Deprivation	Health Deprivation and Disability and Living environment domains only
UV 60	Amenities	With/Without central heating, shared or sole use of bath/shower and toilet
UV 61	Lowest floor level	Lowest floor level of accommodation: Ground, 1st floor, 2nd floor, 3rd floor, 4th floor or 5th floor+. Proxy for areas with high rise flats
UV 65	Household composition	One or two person household split by pensioner/ non-pensioner and children/no children
	Government Office Region	LLSOA to Government Office Region lookup table from Office of National Statistics

It was agreed that only household and population characteristics that were outside of the control of the consumer should be used in the modelling. For example the number of rooms in a house and the number of people living in the same household will impact on the amount of energy consumed and so should be included as potential characteristics for the modelling. However the income of a household, although correlated with energy consumption (as discussed below), is not included. Including this variable in the model would preclude us from the potential to target high income households and given that these households tend to consume more energy than low income households even after accounting for other household characteristics, it would be sensible to target them.

The relationship between energy consumption and household income is discussed below in advance of presenting the final models which excluded this as an explanatory variable.

Correlation between Energy Consumption and Household Income

Income estimates are not readily available at the LLSOA level, so in order to evaluate the relationship between household income and household energy consumption, data were aggregated to the MLSOA level. Household income data are available at this level through the ONS, who have made publicly available their 2007 figures obtained through small area estimation techniques. Energy consumption by MLSOA was calculated by taking an average of the consumption values of the LLSOAs that comprise each MLSOA, weighted by the LLSOA population (ONS 2007 mid-year estimates).

The scatter chart for average income against gas consumption shows a positive trend, with a correlation coefficient of 0.412 (note that the graph displays the R-Sq. value of 0.1698 by default; the correlation coefficient can be calculated by taking the square root of this value). Similarly, the scatter plot for average income against electricity consumption also shows a positive trend. The correlation coefficient for this relationship is 0.459. These correlation coefficients show there is a relatively strong positive relationship between consumption and income (the closer the coefficient is to1.0 the stronger the positive correlation).

Chart 10 – Scatter plot to show the relationship between gas consumption and income

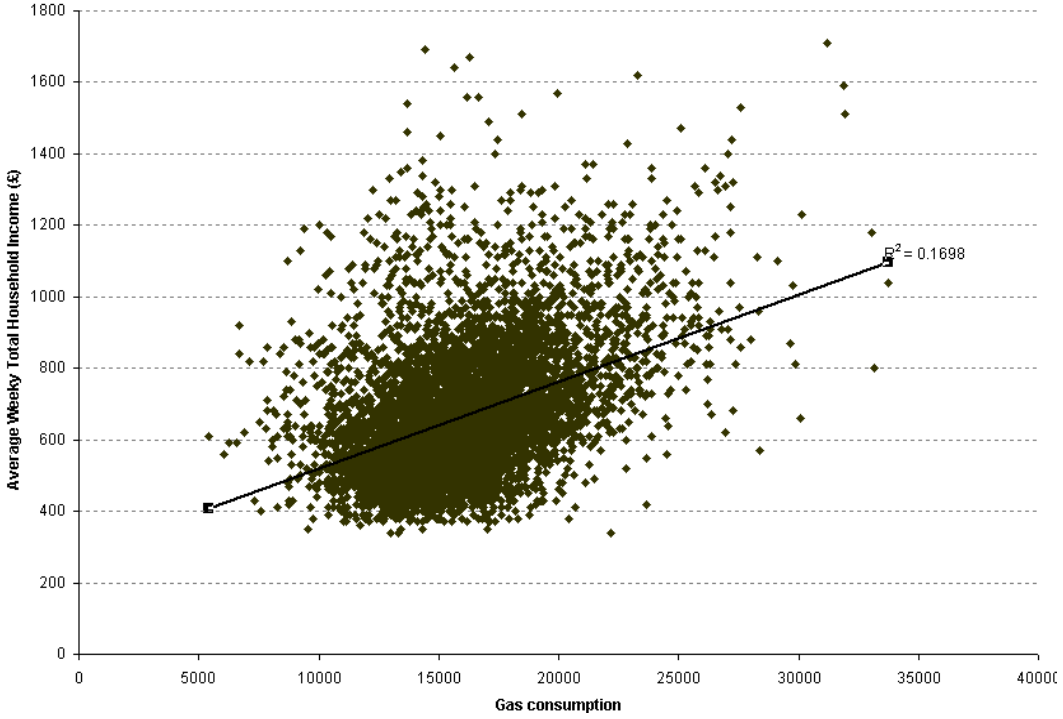
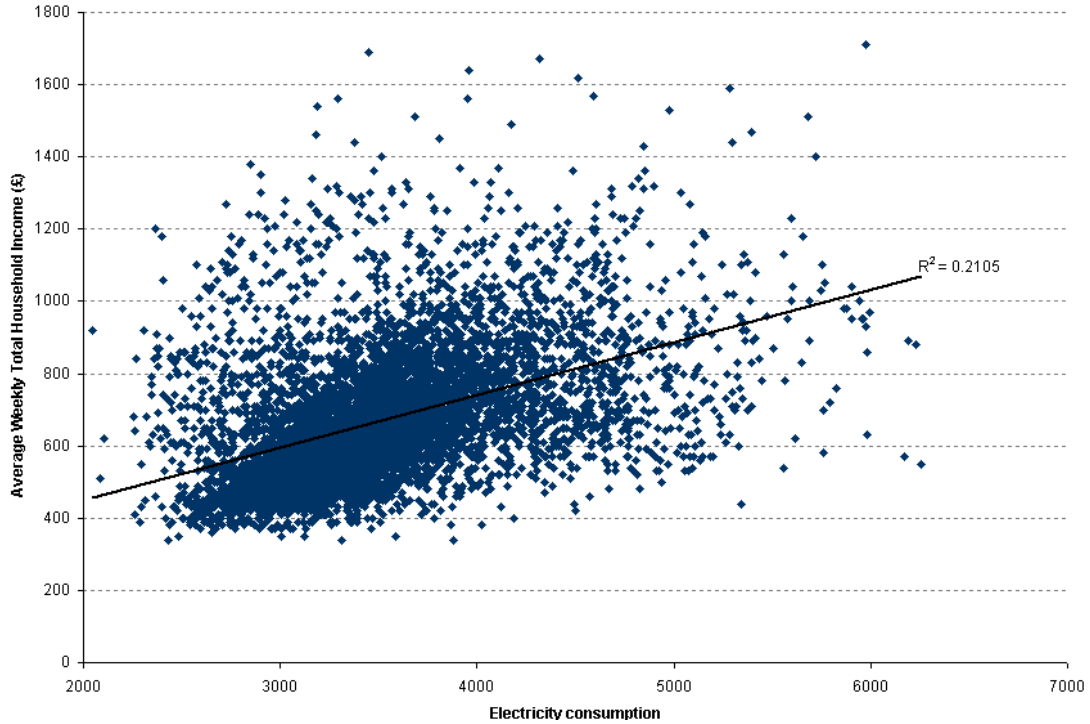


Chart 11 – Scatter plot to show the relationship between electricity consumption and income



Energy Consumption by GOR

The relationship between energy consumption values and region of the UK. The final model includes Government Office Region (GOR) as an explanatory variable because substantial differences are found in average gas consumption by GOR. At one extreme is Scotland, where households use over 1,000 kWh of gas annually more than both Yorkshire & Humber and North East (whose gas consumption levels are roughly equal). At the other extreme is the South West; with household consumption levels at over 3,000 kWh less than Scotland and over 1,000 kWh less than the second-lowest gas participants (London). These findings reflect the prevailing climatic differences of the regions, with Scotland being consistently the coldest region and the South West being the mildest.

There are similarly substantial differences in electricity consumption by GOR. The highest electricity participants are the South East, East of England, and South West regions, while the North East is clearly the lowest electricity consumer, followed by Yorkshire & Humber and London.

The average gas and electricity consumption at an LLSOA level within each government office region is shown in Charts 12 and 13 below.

Chart 12 – Average gas consumption by government office region (GOR)

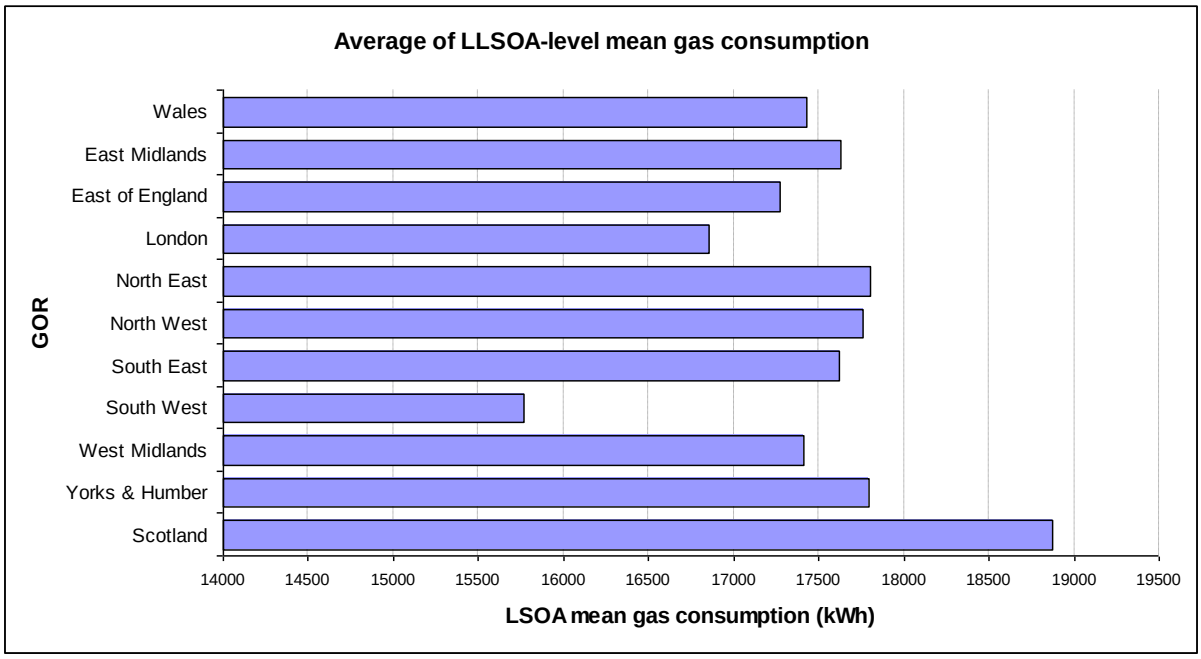
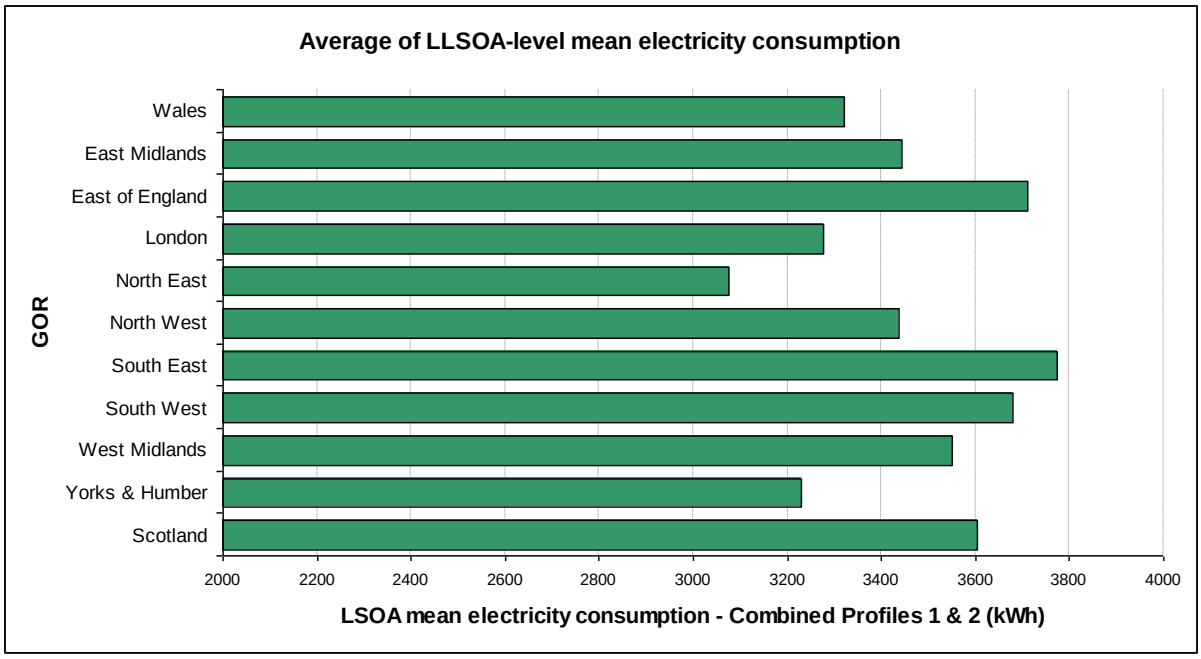


Chart 13 – Average gas consumption by government office region (GOR)



Correlation between Energy Consumption and other household and residential variables

An initial check on the bi-variate relationships between the consumption data and the household and residential characteristics identified those characteristics with a particularly strong relationship. The strongest of all of the covariates with both electricity and gas consumption was the size of the household. The size of the household was calculated based on census table UV57[35]. Below we can see scatter charts 14 and 15 which show the strength of the relationship between the average number of rooms per household in each LLSOA vs. the median gas and median profile 1 electricity consumption.

The correlation coefficient[36] for gas is 0.718 and for profile 1 electricity it is 0.778. This demonstrates a very strong positive relationship between energy consumption and household size (a coefficient of 1.0 would demonstrate a perfect correlation between the two variables). The correlation coefficients for all the contextual variables that relate to each of the census/admin tables in Table 4 above are provided in the additional information section towards the end of this document.

[35] The average number of rooms per household was calculated from census data on the proportion of households in each LLSOA/IGZ with 1, 2, 3 ,…,11+ rooms. For example if an LLSOA had 40% ho households with 1 room, 30% with 2 and 30% with 4. Then the average number of rooms per household for that LLSOA is simply 0.4*1 + 0.3*2 + 0.3*4 = 2.2.

[36] Correlation is a measure of the level of association between two variables. Strictly speaking, it measures linear association, that is, the extent to which a unit change in a variable will lead to a proportional change in another variable. If for example, we take a sample of households, plot their annual gas consumption on the x-axis of a scatter-plot and their annual electricity consumption on the y-axis, we would expect to see a pattern emerging whereby households that consume a lot of gas would also consume a lot of electricity, and those who consume a relative low amount of gas would also consume a relatively low amount of electricity. This pattern would be seen in the scatter-plot as a cloud of points that approximately follow a 'line of best fit' running from the bottom-left corner to the top-right corner. The extent to which the points follow the line of best fit defines the level of association. If the points lie very close to the line, then the level of association is high. The further away the points are from the line of best fit, the lower the level of association. The most commonly-used measure of this association is the Pearson Product Moment Correlation Coefficient (often simply known as the 'Correlation Coefficient'). This measure has a maximum value of 1 and a minimum of -1. The magnitude (i.e. the value irrespective of whether it is positive or negative) indicates the level of association while the sign indicates the direction of the association. The example given above is known as a positive relationship and would yield a positive correlation coefficient. A negative coefficient would be observed if low values for one variable tend to be paired with high values for the other variable.

Based on table of coefficients (Table 4), the main explanatory factors tend to be associated in some form with the size of the household and the number of people living in a household. Accounting for these two contextual variables explains over half of the total variation in LLSOA/IGZ level energy consumption.

Chart 14 – Chart showing relationship between median gas consumption and average number of rooms per household

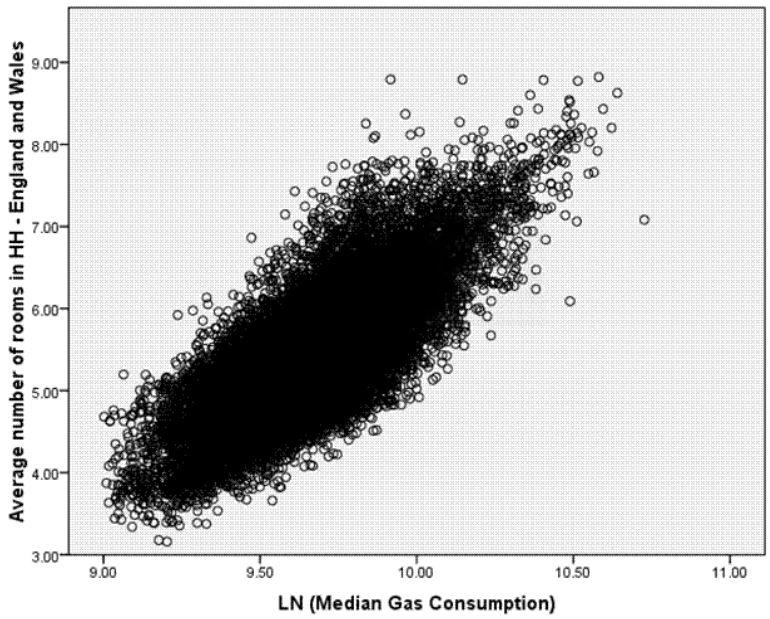
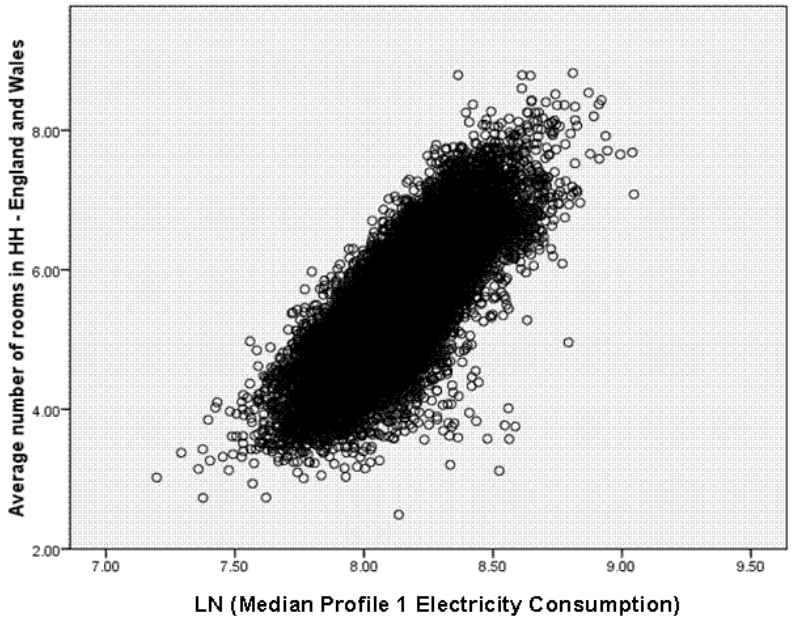


Chart 15 – Chart showing relationship between median profile 1 electricity consumption and average number of rooms per household



Linear regression models were used to estimate the expected median gas and electricity consumption estimates at the LLSOA/IGZ level. Models were run separately for median profile 1 electricity consumption and median combined (profile 1 and 2) electricity consumption. A forward stepwise model selection process was used to identify the key household/residential characteristics from those listed in table 5. The first step adds in the contextual variable with the strongest relationship with energy consumption, at the second step the contextual variable that can explain the most amount of the residual

variation in consumption is included. The process continues until no more residual variation can be explained by any of the contextual variables currently not in the model.

Due to high collinearity between the contextual variables one or more of them were excluded from the model at each step to reduce problems associated with multicollineary, specifically; inflated standard errors and large changes in the coefficient's estimates due to small changes in the data. The final models could all explain a high amount of the total between LLSOA/IGZ variation in consumption with a minimal number of covariates. Estimates of the expected median consumption for gas, electricity (profile 1 and combined) were calculated from these models for all eligible LLSOAs/IGZs in Great Britain. The key characteristics that went into each model can be found in the section called 'final models' along with information on model fit.

Prior to running the models a few **data issues** were addressed, these are discussed in more detail below.

- **Positively skewed median benchmark estimates**

From an examination of the normal probability plot there was evidence to suggest that the residuals of our models based on the actual median benchmark estimates were not normally distributed. This was due to the median distribution being positively skewed. Therefore the median benchmark estimates were transformed using the natural log. These transformed estimates were used in the linear regression models for both gas and electricity. The expected natural log of the median from the final model(s) was then transformed back to the expected median by taking the exponential.

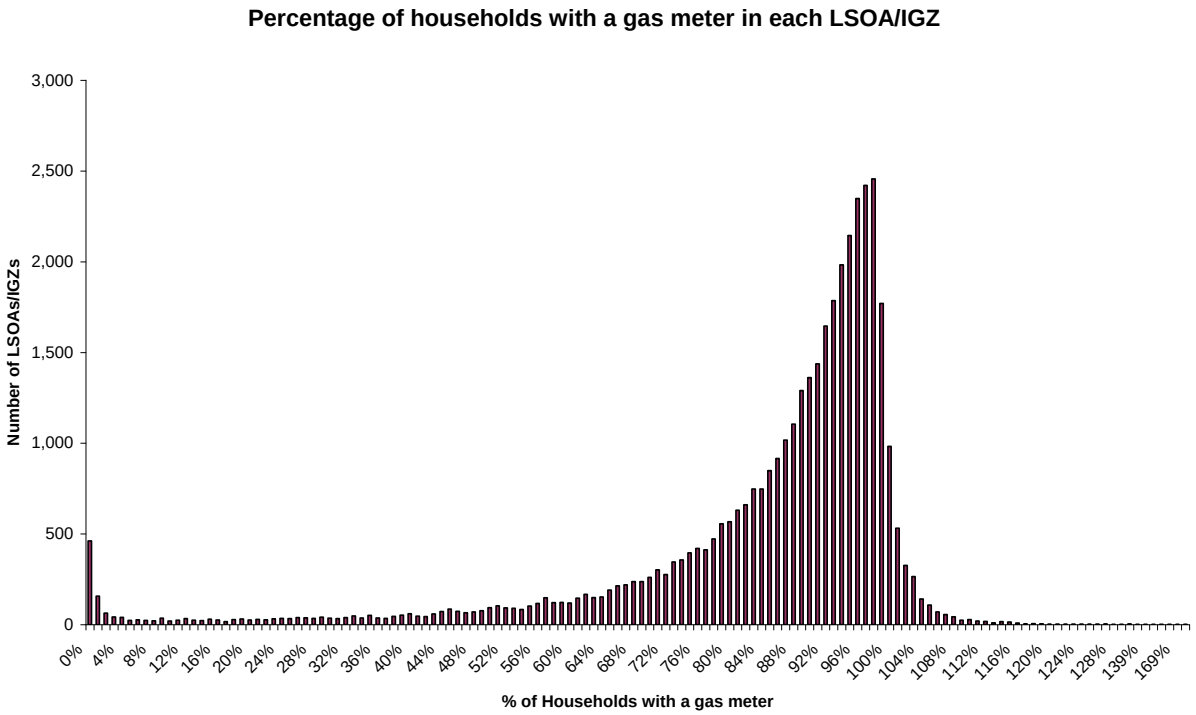
- **Households that are 'off the gas grid'**

Approximately 3.6 million households across the UK are not connected to the mains gas grid[37]. These off-grid households tend to be located in more rural geographical areas and are therefore likely to be located in close proximity to one another. LLSOAs with a high number of off-grid households will cause problems for the modelling, as they are likely to lead to model misspecification. For example, a simple regression model using housing type (% detached, % flats etc.) as predictor of gas consumption we would find that for two LLSOAs (A and B) with the same type of housing (e.g. 80% flats, 20% detached) our model would estimate them both to have the same expected level of gas consumption. However, if we took the scenario where all households in LLSOA A had mains gas whilst in LLSOA B 40% were off the grid, estimates would not be accurate the households off the grid were different in their housing type. For example if the households off the grid in LLSOA B were 50% detached and 50% flats, then the actual profile of the households on the gas grid in LLSOA B would be entirely made up of flats (100%), thus we would expect LLSOA B to have a lower average consumption than LLSOA A, on the assumption that flats consume less gas than detached houses.

To try and minimise the impact of LLSOAs/IGZs with high numbers of households off the gas grid we calculated an approximate 'gas coverage' indicator for each LLSOA/IGZ. This was calculated by dividing the number of domestic gas meters by the total number of dwellings (based on 2008 ONS estimates). The spread is shown in Chart 16.

[37] According to the Office of Fair Trading 'Off-Grid Energy Market Study' – March 2011 (http://www.oft.gov.uk/shared_oft/market-studies/oft1302f.pdf)

Chart 16 – Percentage of on-gas grid households across each LLSOA



The distribution of the red bars indicates that a large number of LLSOA/IGZ's have around 100 percent of the households on gas. However, around 23% of LLSOA's had less than 80% gas coverage (with 1% having no gas). There are also 4% of LLSOA's with over 100% gas coverage (the majority of these within 100-105%), this could indicate that some electricity meters are missing or it could be due to the way 'domestic gas' is defined. For the gas consumption figures a domestic meter is defined as one where less than 73,200KWh is used in a year, this definition is thought to include some small businesses, whereas for electricity the definition of 'domestic' is thought to be more robust as domestic dwellings have a different meter profile number (1 or 2).

LLSOA/IGZ's with a gas coverage indicator of over 80% were included in the gas consumption modelling. This means that around 77% of LLSOA/IGZ's were used. Table 6 shows how this proportion varies by region and country. The results are in-line with expectations, for example, only 66% of the LLSOAs in the south-west and 67% of the IGZs in Scotland are included, where there are known to be areas in Cornwall and Scotland off the gas network.

Table 6 – Proportion of households estimated to be on the gas grid by region

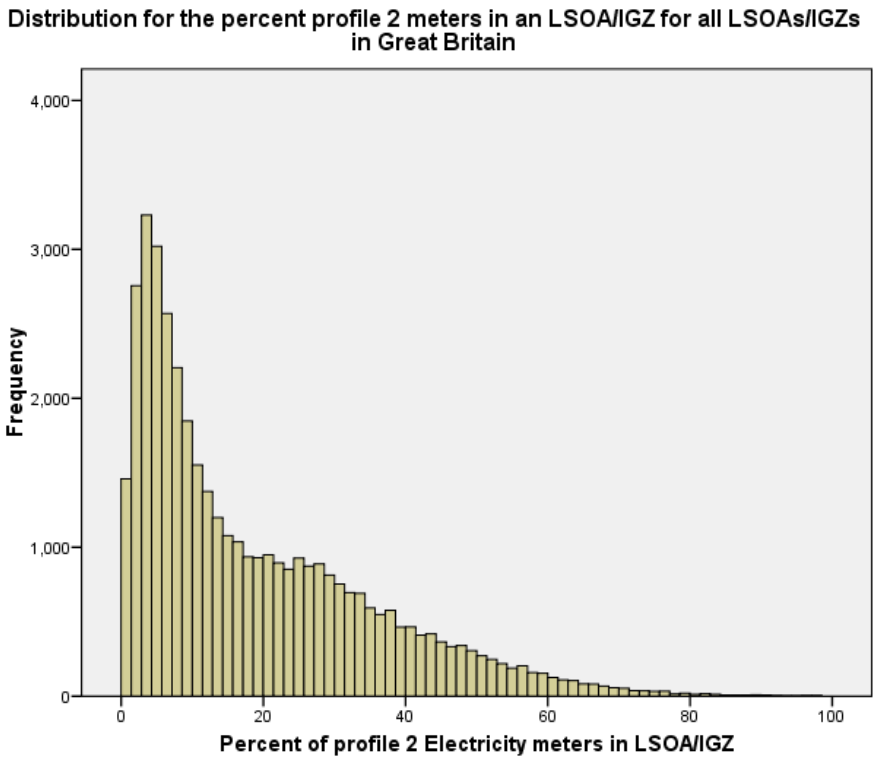
Country	Government Office Region	% of households estimated to be on the gas grid
England	East Midlands	85%
	East of England	75%
	London	86%
	North East	91%
	North West	88%
	South East	78%
	South West	66%
	West Midlands	84%
	Yorkshire and The Humber	86%
England		82%
Scotland		67%
Wales		80%

- **Profile 2 only households**

Due to the very small percentage of households in an LLSOA/IGZ that are on profile 2 electricity we cannot build a separate model to predict the expected median consumption of profile 2 only households in each LLSOA/IGZ in Great Britain. This is because the predictors available to us at the LLSOA/IGZ level are summary measures for all households/people in the LLSOA/IGZ not just those households on profile 2. The same issues arise here that were discussed in the section above for households off the gas grid, i.e. we cannot guarantee that the household and residential characteristics of profile 2 only households is the same or very similar to the household and residential characteristics of all households/people in the LLSOA/IGZ. Neither can we be sure that even if they were the relationships between the consumption behaviour of profile 2 only households and their household/residential characteristics would be consistent with those found based on the combined consumption of profile 1 and 2 households. Chart 17 shows the distribution of LLSOAs/IGZs based on the percentage of profile 2 meters in an LLSOA/IGZ. As we can see the majority of LLSOAs/IGZs have a very small percentage of their total electricity meters on profile 2, with 77% of LLSOAs/IGZs below 30%.

Given the obvious difference in the amount of electricity consumed by households on profile 1 compared with those on profile 2, an indicator was calculated based on dividing the total number of profile 2 meter points in an LLSOA/IGZ by the total number of electricity meters in an LLSOA/IGZ. This indicator was included as a predictor when running the regression models.

Chart 17 – Distribution of Profile 2 electricity meters across LLSOAs/IGZs



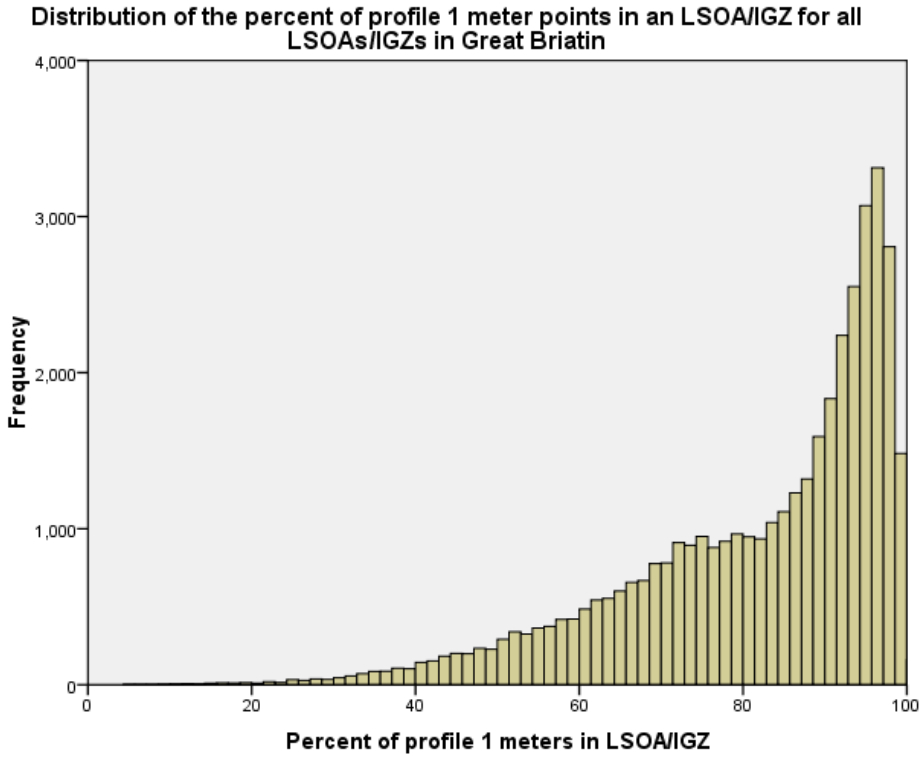
- **Profile 1 only households**

To build a separate model to predict median electricity consumption at the LLSOA/IGZ level for profile 1 only households we had to restrict the model to only those LLSOAs/IGZs where a reasonably high percentage of the households use profile 1 domestic electricity. Chart 18 shows the frequency distribution for all LLSOAs/IGZs in Great Britain based on the percentage of profile 1 households in an LLSOA/IGZ. As we can see the percentages tend to range from 20% to 100%, with most concentrated between 90% and 100%. Table 7 shows the percentage of the LLSOAs/IGZs we would include in our model at a number of cut-off values. A balance must be struck between the number of LLSOAs/IGZs we use in the model and the percentage of profile 1 households in the LLSOA/IGZ. Given there is a steep drop off after 70% in the number of eligible LLSOAs/IGZs the decision was made to use 70% or above as the cut-off value. This ensures that we have incorporated the majority of the LLSOAs/IGZs in the model, whilst also reducing the potential for mis-specifying the model due to the inclusion of LLSOAsIGZs with a low proportion of households using profile 1 electricity.

Table 7 – Proportion of LLSOAs/IGZs within each criterion

Criterion (cut-off value)	Percent of LLSOAs/IGZs included in model
> 50%	95%
> 60%	89%
> 70%	78%
>80%	63%
> 90%	43%

Chart 18 – Distribution of Profile 1 electricity meter points across LLSOAs/IGZs



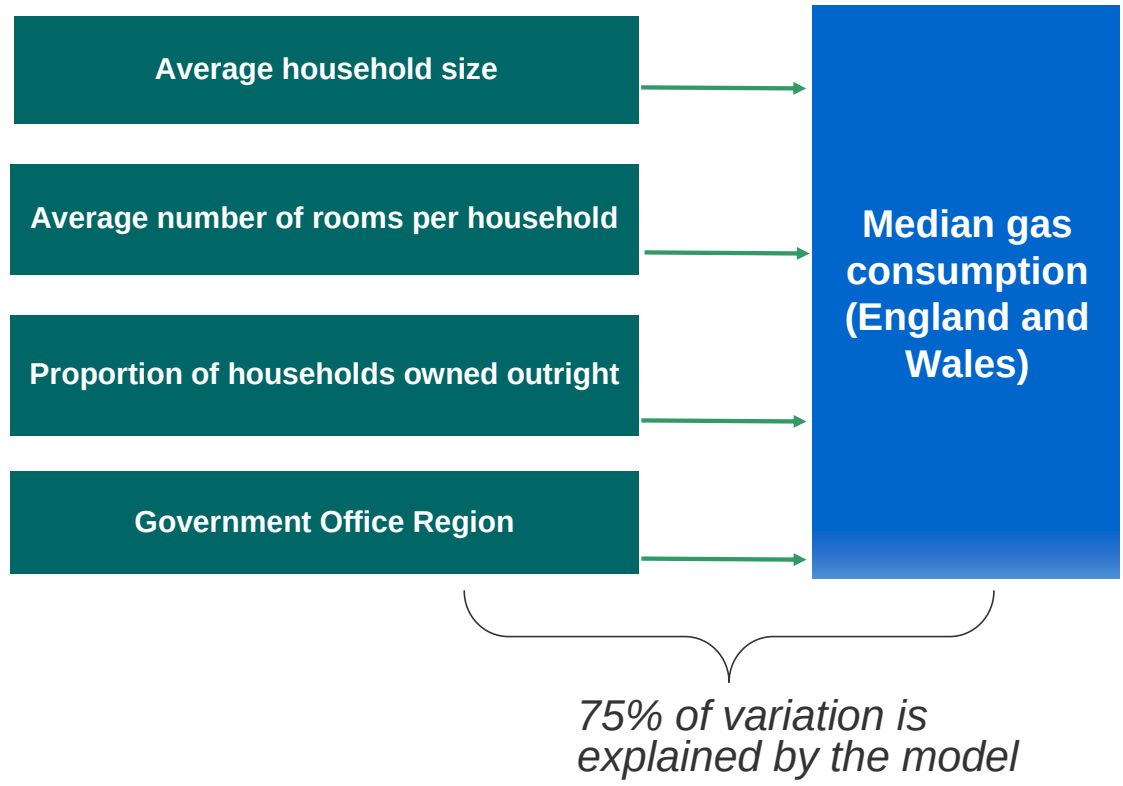
- **Inconsistencies between England, Scotland and Wales**

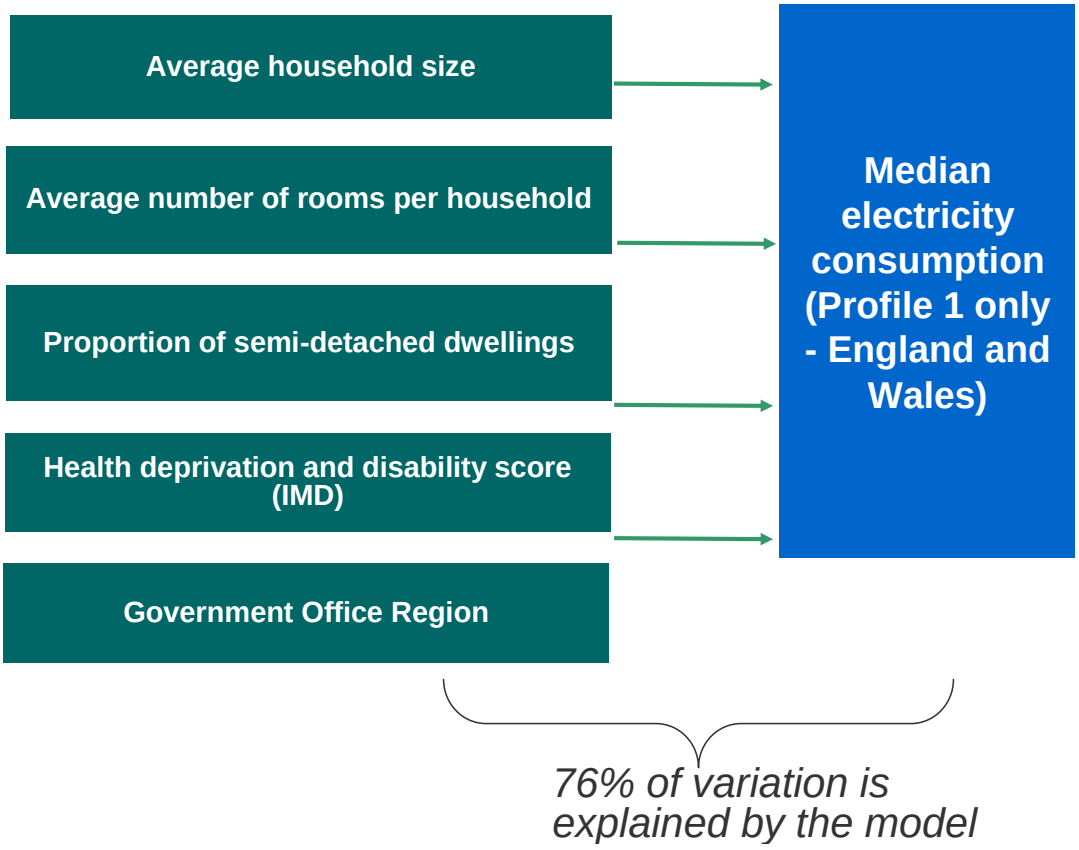
There were a number of inconsistencies in how the household and residential characteristics are measured for Scotland compared to England and Wales. For example there was no information on the number of people living in a household for Scottish IGZs. Secondly, the calculation of the Indices of Deprivation domains is inconsistent across the 3 countries and therefore not directly comparable[38]. Lastly, the approach used in Scotland to calculate IGZs compared to the English and Welsh LLSOAs is different. In light of these inconsistencies two separate models were built for each consumption type (Gas/Electricity), one for England and Wales and another for Scotland.

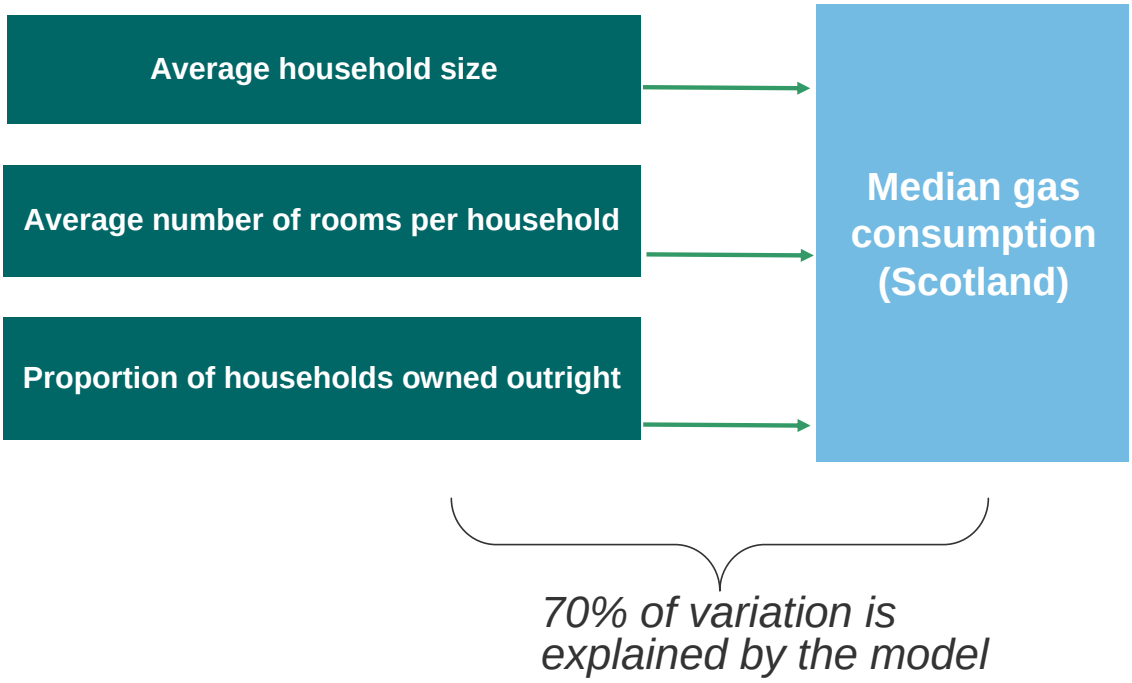
38 http://www.neighbourhood.statistics.gov.uk/dissemination/Info.do?page=analysisandguidance/analysisarticles/indices-of-deprivation.htm

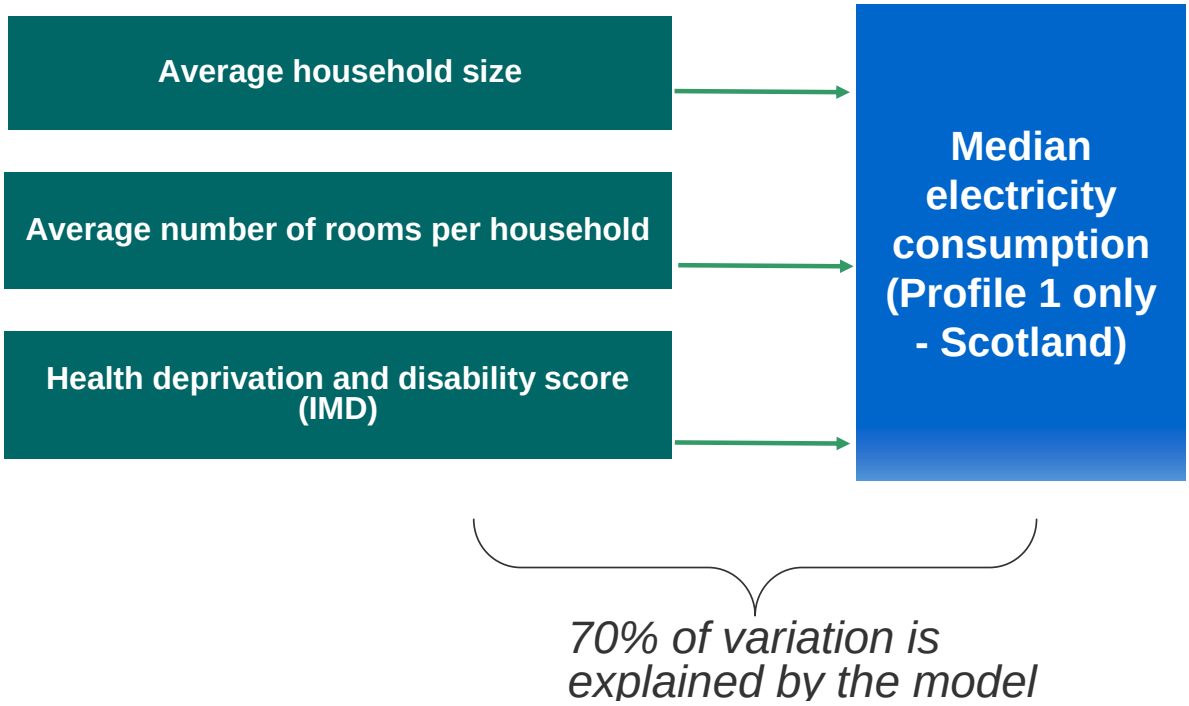
Final Models

The following diagrams show the explanatory variables which have been included within each of the models to explain levels of energy consumption. The formulae for the final models are also included below.






Average household size
Average number of rooms per household
Proportion of households owned outright
Median gas consumption (Scotland)
70% of variation is explained by the model


Average household size
Average number of rooms per household
Health deprivation and disability score (IMD)
Median electricity consumption (Profile 1 only - Scotland)
70% of variation is explained by the model

Gas median consumption models

England and Wales

$$f(y) = \alpha + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 (X_1 * X_4) + b_6 (X_2 * X_4) + b_7 (X_3 * X_4)$$

Where;

$f(y)$ = Natural log of median gas consumption
X_1 = Average household size
X_2 = Average number of rooms per household
X_3 = Proportion of households owned outright
X_4 = Government office region

and α and b_1 to b_7 are the parameter estimates for the model.

R^2 = 75.4%[39]

Scotland

$$f(y) = \alpha + b_1 X_1 + b_2 X_2 + b_3 X_3$$

Where;

$f(y)$ = Natural log of median gas consumption
X_1 = Average household size
X_2 = Average number of rooms per household (proxy)[40]
X_3 = Proportion of households owned outright

and α and b_1 to b_3 are the parameter estimates for the model.

R^2 = 69.8%

[39] R^2 is an indicator of model fit. It provides a measure of how much of the total amount of variation in consumption at the LLSOA/IGZ level is explained by the model

[40] Information on the number of people in a household was not available on the Scottish Neighbourhood Statistics (SNS) website. Therefore a proxy was used based on dividing the total number of dwellings in an IGZ by the total number of people in the IGZ. Both sources of data are based on 2009 estimates.

Profile 1 Electricity median consumption models

England and Wales

$$f(y) = \alpha + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 +$$
$$b_6 (X_1 * X_5) + b_7 (X_2 * X_5) + b_8 (X_3 * X_5) + b_9 (X_4 * X_5) + b_{10} (X_5 * X_5)$$

Where;

$f(y)$ = Natural log of median electricity consumption
X_1 = Average household size
X_2 = Average number of rooms per household
X_3 = Proportion of semi-detached dwellings
X_4 = Health deprivation and disability score (IMD Domain)
X_5 = Government office region

and α and b_1 to b_{10} are the parameter estimates for the model.

Profile 1 consumption R^2 = 73.1%

Scotland

$$f(y) = \alpha + b_1 X_1 + b_2 X_2 + b_3 X_3$$

$f(y)$ = Natural log of median electricity consumption
X_1 = Average household size
X_2 = Average number of rooms per household
X_3 = Health deprivation and disability score (IMD Domain)

and α and b_1 to b_3 are the parameter estimates for the model.

Profile 1 consumption R^2 = 75.8%

Combined Electricity median consumption models

England and Wales

$$f(\hat{y}) = \alpha + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 +$$
$$b_7(X_1 * X_6) + b_8(X_2 * X_6) + b_9(X_3 * X_6) + b_{10}(X_4 * X_6) + b_{11}(X_5 * X_6)$$

Where;

$f(y)$ = Natural log of median electricity consumption
X_1 = Average household size
X_2 = Average number of rooms per household
X_3 = Proportion of semi-detached dwellings
X_4 = Health deprivation and disability score (IMD Domain)
X_5 = Proportion of meter points on profile 2
X_6 = Government office region

and α and b_1 to b_{11} are the parameter estimates for the model.

Combined consumption R^2 = 68.6%

Scotland

$$f(\hat{y}) = \alpha + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4$$

$f(y)$ = Natural log of median electricity consumption
X_1 = Average household size
X_2 = Average number of rooms per household
X_3 = Health deprivation and disability score (IMD Domain)
X_4 = Proportion of meter points on profile 2

and α and b_1 to b_3 are the parameter estimates for the model.

Combined consumption R^2 = 74.8%

Checks on the assumptions of the models are provided in the additional information section below under 'Model Outputs'. Plots showing the observed vs. the predicted values can be used to detect evidence of non-linearity and plots showing the residuals vs. the predicted can be used to detect homoscedasticity, whilst the normal Probability Plot (P-P) of the residuals is used to detect violations from normality. There is no evidence to suggest that the assumptions of the models are not met.

Additional information

The following table is a list of the gas consumption values that were excluded due to higher than expected frequencies (criterion 5).

Gas consumption kWh value	Number of meter points
300	2,102
8,815	6,526
9,170	4,045
9,585	7,402
9,960	4,886
10,639	15,588
11,130	9,936
11,270	22,063
11,659	9,164
12,100	16,842
12,335	4,306
13,070	7,252
13,120	5,748
13,420	7,650
13,530	10,613
14,255	4,579
14,348	5,333
14,611	10,446
15,150	7,329
17,000	6,815
17,500	4,130
18,000	12,022
19,000	11,070
19,823	4,484
20,000	3,271
20,017	3,293
20,044	3,800
20,600	95,259
20,715	3,714
21,195	8,300
22,500	7,741
22,690	4,691
24,290	3,376
30,000	1,522
30,035	1,717
31,176	848
34,160	1,622
35,000	574
36,890	679
40,000	423
45,000	279
48,000	322
50,000	430
54,000	80
55,000	113
60,000	499
63,000	60
64,000	440
65,000	125
66,000	46
70,000	178
72,000	56
73,000	77
Total	343,866

The following tables list the electricity consumption values that fall into criterion 4 as defined under the heading ‘Electricity Consumption data’ on p12 of this annex. Although this criterion is not described in more detail, the same logic is applied as the Gas Consumption equivalent criterion.

Profile 1 consumption values excluded due to higher than expected frequencies.

Profile 1 Electricity consumption kWh per annum	Number of meter points
3,098	13,935
3,582	7,352
3,699	5,086
3,700	9,155
3,902	6,910
Total	**42,438**

Profile 2 consumption values excluded due to higher than expected frequencies.

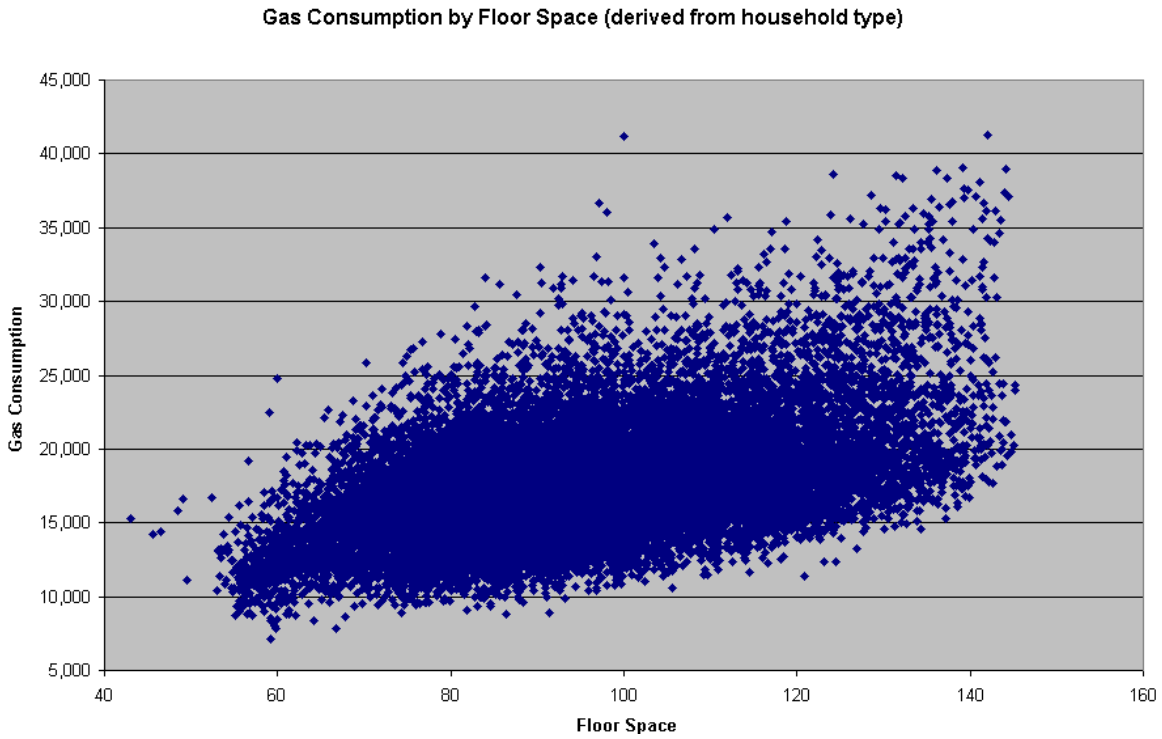
Profile 2 Electricity consumption kWh per annum	Number of meter points
3,000	2,312
5,568	1,259
6,132	937
6,934	609
7,503	838
8,120	462
8,544	1,767
9,481	615
9,552	482
17,762	194
30,874	133
Total	**9,608**

Correlations between Contextual Variables and median Energy Consumption

The following table displays the LLSOA/IGZ-level correlations between the median gas and electricity (profile 1 and combined profiles 1 and 2) consumption figures and a variety of contextual variables. Some of the key relationships shown in this table are described below along with visual depictions of the strength and direction of the correlation with energy consumption (gas consumption is used to illustrate the relationship in all cases, although the pattern for electricity consumption is very similar).

Household Type – Areas with a high proportion of houses, particularly detached houses, show the greatest tendency to use more energy than any other household types. This is consistent across all three measures of energy consumption. Areas with a high proportion of flats maisonettes and apartments show the greatest tendency to use less energy, and this also applies across all three consumption measures. Areas with high concentrations of caravans, mobile homes and other temporary structures tend to consume more electricity, but this trend is much less pronounced for gas.

Chart 19 – Scatter plot to show relationship between gas consumption and floor space



Central Heating –Areas that are well-served with gas central heating consume more energy than those that do not. The findings are consistent for all three measures, but slightly less pronounced for the combined electricity measure.

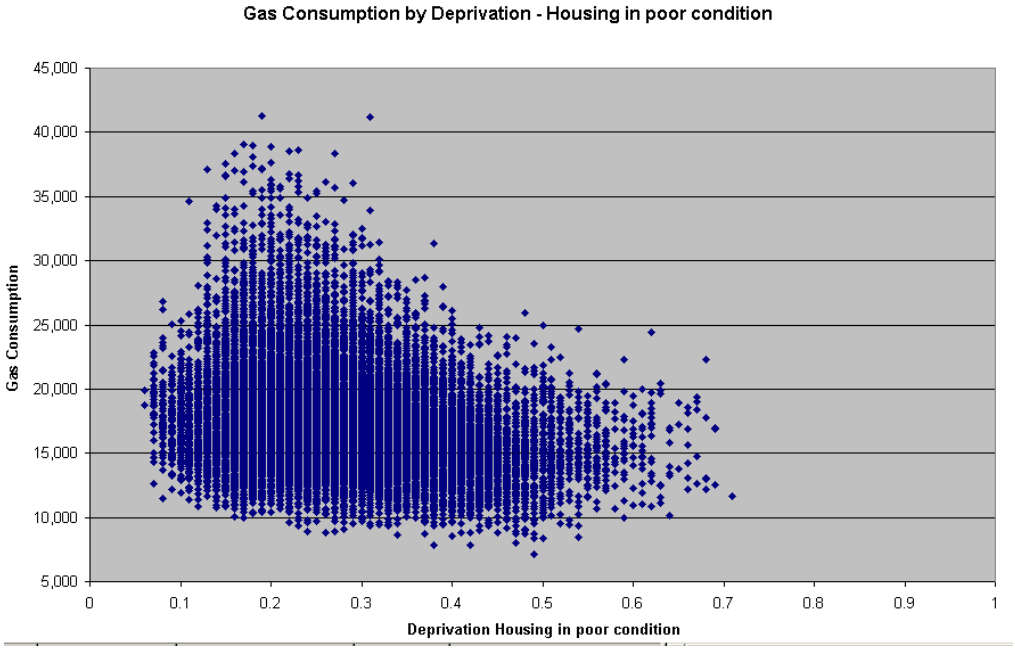
Children in household – On the whole, the age of the dependent children serves as an indicator to the amount of energy used within a household. Areas with a high proportion of young children tend to use less energy (particularly gas) than areas with a high proportion of older children.

Limiting, long-term illness (LLTI) – Consumption is lower for areas with a high proportion of households that contain at least one person with an LLTI (particularly electricity consumption).

Household composition – Areas with a high concentration of married couples tend to use more energy than areas with many cohabiting couple family households, lone-parent households and one person households. This finding is particularly pronounced for areas with a high proportion of married couple households with no dependent children.

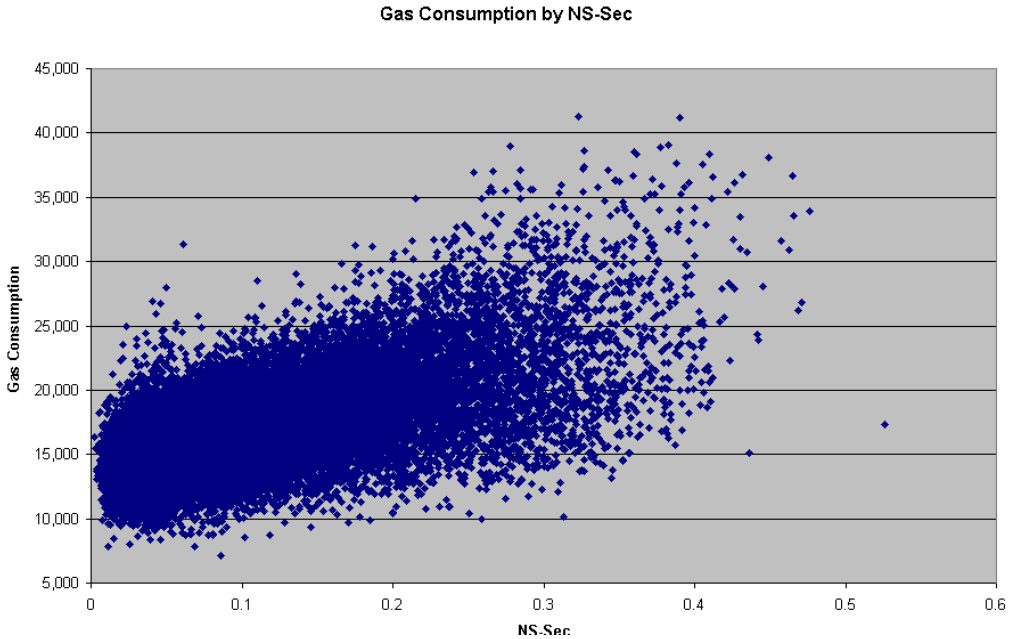
Poor housing index – Households that have selected characteristics in one dimension do not tend to display particularly high or low consumption, but those that have selected characteristics in more than dimension show a marked trend in low consumption.

Chart 20 – Scatter plot to show relationship between gas consumption and deprivation



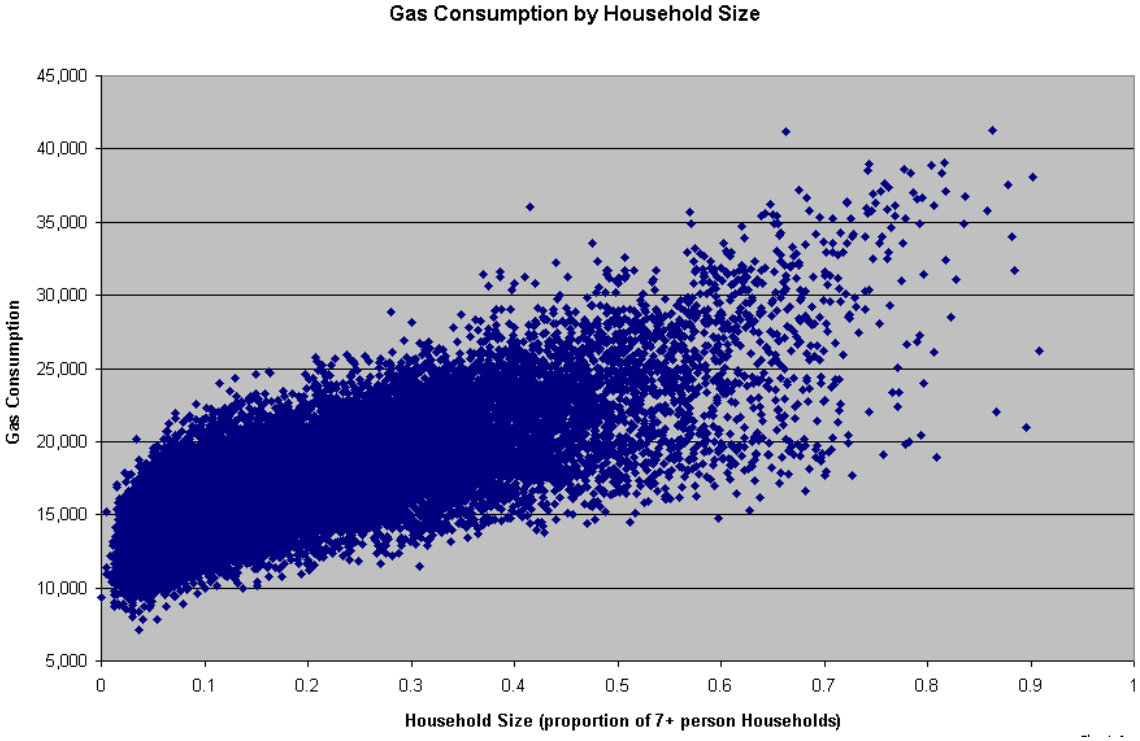
NS-SEC – Areas with high proportions of higher social grades tend to use more gas and electricity.

Chart 21 – Scatter plot to show relationship between gas consumption and social grade



Number of people in household – A positive association is found generally between the average number of occupants per household and energy consumption at the area level. This trend is particularly noticeable in ordinary domestic (i.e. not Economy 7) electricity consumption.

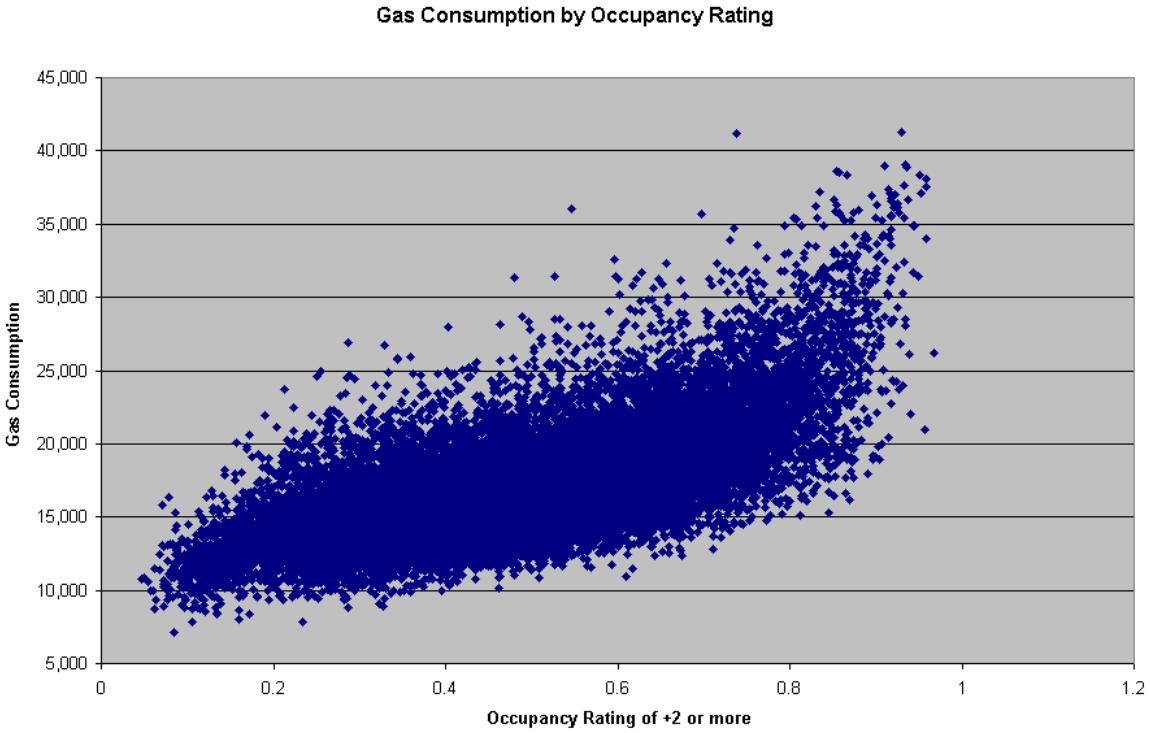
Chart 22 – Scatter plot to show relationship between gas consumption and household size



Number of rooms per household – A very strong correlation is found between the average number of rooms per household within an area and the amount of energy consumed.

Occupancy Index – Only areas with an occupancy rating of +2 or more are observed to have high levels of energy consumption.

Chart 23 – Scatter plot to show relationship between gas consumption and occupancy rating



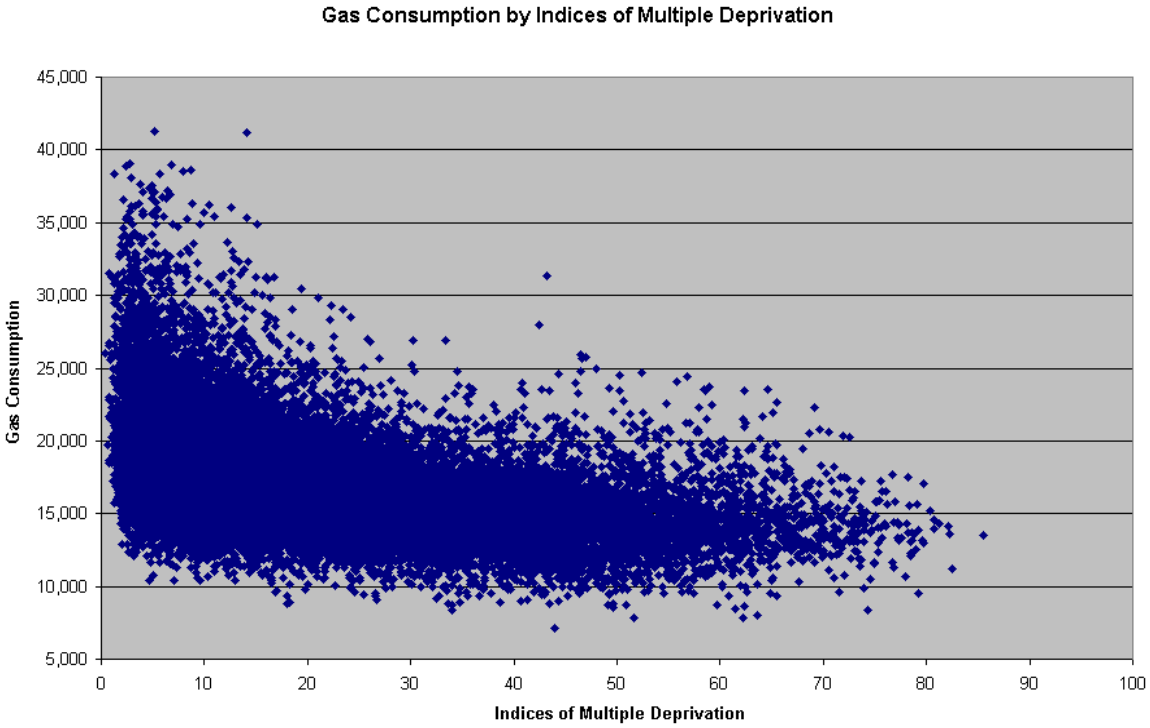
Tenure – Areas that are dominated by owner-occupied properties tend to be high participants of energy (though less pronounced for Economy 7 electricity). This trend is not observed in areas with high proportion of shared-ownership property.

Indices of Multiple Deprivation – For all indices bar one, high deprivation scores are associated with low consumption. The exception is with the Barriers to Housing and Services measure, where no strong association is seen in gas consumption and a fairly weak association is seen in electricity consumption.

The chart below shows that the relationship between gas consumption and IMD is not perfectly linear. There is a greater variation in consumption within LLSOAs of lower IMD than LLSOAs of higher IMD.

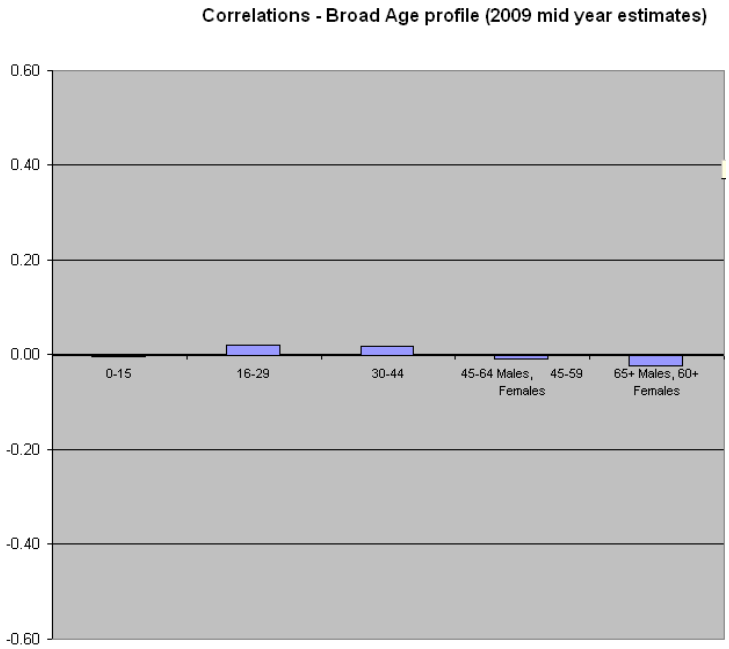
It is possible that this difference in variation can be attributed to the differences of variation in property size. Whereas areas of high IMD areas tend to be fairly homogenous in terms of rurality and the type of properties (high proportion of local authority apartments, combined with modest-sized privately owned apartments and houses within inner-city neighbourhoods), areas of low IMD could be desirable city-centre/ waterfront properties, mansion block apartments or suburban family homes or modern conversions of old buildings such as churches and warehouses as well as large houses in affluent rural locations.

Chart 24 – Scatter plot to show relationship between gas consumption and indices of multiple deprivation



Age and gender – no strong associations were found between age and gender area profiles and energy consumption. This is demonstrated for age in chart 25 below. It shows the correlation coefficient for each of the age brackets when tested against levels of gas consumption. The scores on the y-axis range from 0.6 (fairly strong positive correlation) to -0.6 (fairly strong negative correlation). The concentration of each age bracket around 0 shows that there is no relationship between age and gas consumption.

Chart 25 – Relationship between gas consumption and age



The full list of variables tested for inclusion in the models is presented in the table below. The final three columns of this table show the correlation coefficient for each variable when the relationship between that variable is tested against the gas consumption data, the profile 1 electricity data and the combine electricity data. A score of +1.00 shows perfect positive correlation between the variable and the consumption data whereas a score of -1.00 shows perfect negative correlation. In reality most of the scores displayed in the table fall between these two extremes but their sign (positive or negative) displays the direction of the relationship with energy consumption and their size displays the strength of that relationship.

Correlations between Contextual Variables and median Energy Consumption

	Contextual variable	Final LLSOA/IGZ level Median for Gas	Final LLSOA/IGZ Median Electricity Profile 1	Final LLSOA/IGZ level (Profile 1 and 2) Median for Electricity
Household Type	In an Unshared Dwelling	.130	.174	.135
	In an Unshared Dwelling: House or Bungalow	.418	.466	.365
	In an Unshared Dwelling: House or Bungalow: Detached	.511	.621	.608
	In an Unshared Dwelling: House or Bungalow: Semi-detached	.187	.138	.060
	In an Unshared Dwelling: House or Bungalow: Terraced (including end-terrace)	-.304	-.336	-.350
	In an Unshared Dwelling: Flat, Maisonette or Apartment	-.422	-.477	-.378
	In an Unshared Dwelling: Flat, Maisonette or Apartment: In a Purpose-Built Block of Flats	-.442	-.457	-.356
	In an Unshared Dwelling: Flat, Maisonette or Apartment: Part of a Converted or Shared House	-.160	-.249	-.216
	In an Unshared Dwelling: Flat, Maisonette or Apartment: In a Commercial Building	-.125	-.220	-.154
	In an Unshared Dwelling: Caravan or Other Mobile or Temporary Structure	.029	.114	.132
	In a Shared Dwelling	-.130	-.174	-.135
Central Heating	With central heating	.260	.239	.208
	With central heating: With sole use of bath / shower and toilet	.266	.252	.218
	With central heating: Without sole use of bath / shower and toilet	-.101	-.162	-.130
	Without central heating	-.260	-.239	-.208
	Without central heating: With sole use of bath / shower and toilet	-.257	-.234	-.205
	Without central heating: Without sole use of bath / shower and toilet	-.101	-.137	-.100
Children in household	No Dependent Children	.235	.116	.185
	One Dependent Child: Aged 0 to 4 years	-.445	-.380	-.369
	One Dependent Child: Aged 5 to 11 years	-.409	-.369	-.376
	One Dependent Child: Aged 12 to 18 years	.027	.001	-.072
	Two or more Dependent Children: Aged 0 to 4 years	-.221	-.105	-.148
	Two or more Dependent Children: Aged 5 to 11 years	.076	.220	.134
	Two or more Dependent Children: Aged 12 to 18 years	.324	.345	.265
	Total Dependent Children	-.172	-.066	-.130
	One Dependent Child	-.420	-.375	-.399
	Two or more Dependent Children	-.027	.116	.032
	Households with no adults in employment: With dependent children	-.392	-.352	-.366
	Households with no adults in employment: Without dependent children	-.096	-.358	-.278
	Households with dependent children: All ages	.095	.282	.154
	Households with dependent children: Aged 0-4	-.133	.038	-.040
LLTI	Households with one or more person with a limiting long-term illness	-.200	-.380	-.372

Household composition	One person	-.481	-.654	-.513
	One person: Pensioner	-.126	-.375	-.276
	One person: Other	-.486	-.516	-.418
	One family and no others	.455	.622	.506
	One family and no others: All pensioners	.402	.287	.289
	One family and no others: Married couple households	.567	.695	.587
	One family and no others: Married couple households: No children	.468	.583	.549
	One family and no others: Married couple households: With one dependent child	.419	.523	.407
	One family and no others: Married couple households: With two or more dependent children	.484	.621	.509
	One family and no others: Married couple households: All children non-dependent	.453	.470	.349
	One family and no others: Cohabiting couple family households	-.368	-.201	-.172
	One family and no others: Cohabiting couple family households: No children	-.241	-.156	-.097
	One family and no others: Cohabiting couple family households: With one dependent child	-.291	-.168	-.186
	One family and no others: Cohabiting couple family households: With two or more dependent children	-.265	-.092	-.125
	One family and no others: Cohabiting couple family households: All children non-dependent	-.055	.009	-.014
	One family and no others: Lone parent households	-.435	-.354	-.383
	One family and no others: Lone parent households: With one dependent child	-.474	-.413	-.416
	One family and no others: Lone parent households: With two or more dependent children	-.386	-.262	-.295
	One family and no others: Lone parent households: All children non-dependent	-.198	-.211	-.257
	Other households	-.144	-.203	-.203
	Other households: With one dependent child	-.068	-.101	-.148
	Other households: With two or more dependent children	-.014	-.076	-.114
	Other households: All student	-.061	-.080	-.073
	Other households: All pensioner	.072	.001	.028
	Other households: Other	-.184	-.227	-.208
	One Person Households	-.481	-.654	-.513
	One Person Households: 1 adult of pensionable age and no children	-.126	-.375	-.276
	One Person Households: 1 adult of non-pensionable age and no children	-.486	-.516	-.418
	Other Households	.481	.654	.513
	Other Households: 1 adult of any age and 1 or more children	-.466	-.367	-.378
Household Composition cont.	Other Households: 1 adult of non-pensionable age and 1 of pensionable age and no children, or 2 adults of pensionable age and no children	.405	.303	.300
	Other Households: 2 adults and 1 or 2 children	.257	.462	.351
	Other Households: 2 adults of non-pensionable age and no children	.112	.275	.283
	Married couple household with dependent child(ren)	.496	.606	.484
	Married couple household with no dependent child(ren)	.550	.561	.510
	Cohabiting couple household with dependent child(ren)	-.326	-.153	-.184
	Cohabiting couple household with no dependent child(ren)	-.268	-.184	-.125
	Lone parent household with dependent child(ren)	-.453	-.360	-.381
	Lone parent household with no dependent child(ren)	-.200	-.214	-.261

	One person household	-.481	-.654	-.513
	Multi person household: All student	-.061	-.080	-.073
	Multi person household: All other	-.243	-.307	-.274
Poor housing index	Household has no selected characteristic	.414	.504	.448
	Household has selected characteristics in 1 dimension	-.005	.127	.178
	Household has selected characteristics in 2 dimensions	-.318	-.483	-.431
	Household has selected characteristics in 3 dimensions	-.417	-.504	-.492
High rise flats index	Lowest floor level: Basement or semi-basement	-.067	-.183	-.170
	Lowest floor level: Ground floor (street level)	.375	.453	.367
	Lowest floor level: First floor	-.397	-.502	-.408
	Lowest floor level: Second floor	-.362	-.398	-.307
	Lowest floor level: Third or fourth floor	-.330	-.310	-.246
	Lowest floor level: Fifth floor or higher	-.252	-.209	-.154
NS-SEC (Social Grade)	1. Higher managerial and professional occupations	.497	.509	.469
	2. Lower managerial and professional occupations	.369	.423	.379
	3. Intermediate occupations	-.154	-.122	-.170
	4. Small employers and own account workers	.388	.500	.552
	5. Lower supervisory and technical occupations	-.285	-.167	-.187
	6. Semi-routine occupations	-.494	-.457	-.451
	7. Routine occupations	-.423	-.400	-.396
	8. Never worked and long-term unemployed	-.366	-.399	-.397
	Not classified	-.163	-.388	-.321
Number of people in household	1 person living in Household	-.481	-.654	-.513
	2 people living in Household	.322	.367	.372
	3 people living in Household	.151	.318	.172
	4 people living in Household	.397	.569	.424
	5 people living in Household	.201	.294	.199
	6 people living in Household	.021	.013	-.032
	7 people living in Household	.003	-.061	-.080
	8 or more people living in Household	.016	-.082	-.092
	Average number of people in HH - England and Wales	.351	.477	.335

Number of rooms per household	1 room	-.254	-.292	-.232
	2 rooms	-.396	-.443	-.347
	3 rooms	-.495	-.556	-.443
	4 rooms	-.531	-.568	-.478
	5 rooms	-.257	-.185	-.232
	6 rooms	.308	.229	.131
	7 rooms	.616	.628	.549
	8 or more rooms	.639	.713	.687
	Average number of rooms in HH - England and Wales	.718	.778	.695
Over and under occupancy index	Occupancy rating of + 2 or more	.676	.693	.616
	Occupancy rating of + 1	-.492	-.515	-.478
	Occupancy rating of 0	-.632	-.626	-.544
	Occupancy rating of -1	-.457	-.479	-.417
	Occupancy rating of -2 or less	-.287	-.333	-.301
	Up to 0.5 persons per room	.339	.248	.302
	Over 0.5 and up to 1.0 persons per room	-.332	-.208	-.274
	Over 1.0 and up to 1.5 persons per room	-.230	-.250	-.262
	Over 1.5 persons per room	-.203	-.245	-.235

Tenure	Owned	.546	.518	.435
	Owned: Owns outright - England and Wales	.578	.421	.399
	Owned: Owns with a mortgage or loan	.316	.412	.301
	Owned: Shared ownership	-.191	-.115	-.095
	Social rented	-.500	-.459	-.421
	Social rented: Rented from Council (Local Authority)	-.409	-.387	-.371
	Social rented: Other social rented	-.319	-.272	-.219
	Private rented	-.187	-.223	-.133
	Private rented: Private landlord or letting agency	-.196	-.249	-.160
	Private rented: Employer of a household member	.007	.069	.088
	Private rented: Relative or friend of a household member	-.136	-.178	-.111
	Private rented: Other	-.017	.012	.033
	Living rent free	-.160	-.063	.069

Indices of Deprivation	Index of Multiple Deprivation Score	-.474	-.496	-.467
	Income Score	-.464	-.487	-.463
	Employment Score	-.434	-.504	-.480
	Health Deprivation and Disability Score	-.464	-.574	-.559
	Education Skills and Training Score	-.432	-.382	-.377
	Barriers to Housing and Services Score	-.022	.183	.248
	Crime Score	-.320	-.421	-.435
	Living Environment Score	-.333	-.377	-.320
	Housing In Poor Condition	-.260	-.277	-.160
Age and gender profile	0-15	.008	-.019	-.020
	16-29	.027	-.012	-.025
	30-44	.021	.003	-.027
	45-64 Males, 45-59 Females	-.019	.024	.044
	65+ Males, 60+ Females	-.033	.007	.027

Model Outputs – checking the residuals

The following charts are checks that are run to confirm that certain distributional assumptions are valid in the regression models that are produced. The first of these charts plots the residuals against the expected median values. A residual is the difference between the actual value and the value predicted by a model. Using the first set of charts (Gas consumption in England and Wales) as examples, we see that the residuals are:

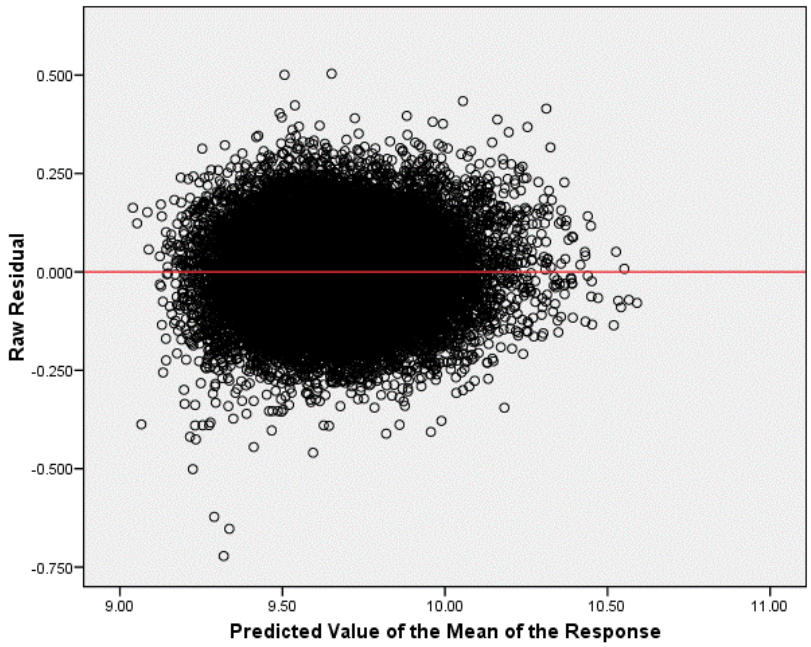
- centred around zero, which shows that the predicted values are not unduly affected by bias.
- display no systematic pattern when plotted against the predicted outcome (i.e. energy consumption). This indicates that the variance of the residuals is constant throughout the range of predicted values.

The second of these charts plots the actual energy consumption values against the predicted values. We would expect the values to be randomly distributed around the x=y line (i.e. the red line on the chart). In this example, we see that this is the case except for the extreme high values and the extreme low values. Some of the low values are over-estimated by the model (i.e. the predicted variables are higher than the actual variables) while for the high values, the model has a tendency to under-estimate. However, these values represent only a few hundred of the tens of thousands of cases, and we should not be unduly worried about this minor departure from the ideal case.

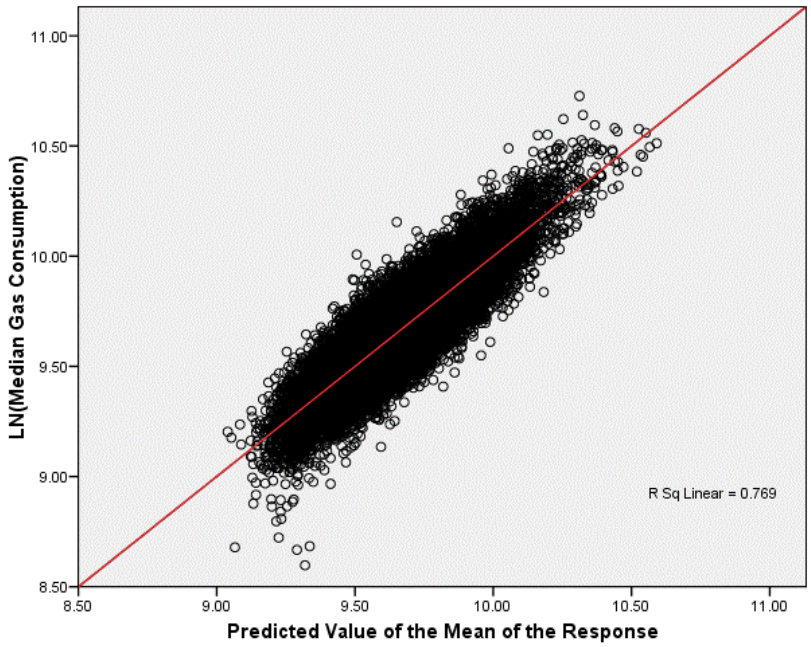
The final chart tests the assumption that the residuals are normally distributed (or at least that the residuals do not depart significantly from a normal distribution). If the residuals are very close to being normally distributed, the points in the chart will form a straight line that closely follows the x=y line. The further the points depart from this line, the more the assumption of normally distributed residuals is violated. In this example, the plot almost perfectly follows the line, so the departure from the normality assumption is minimal.

Gas Model – England and Wales

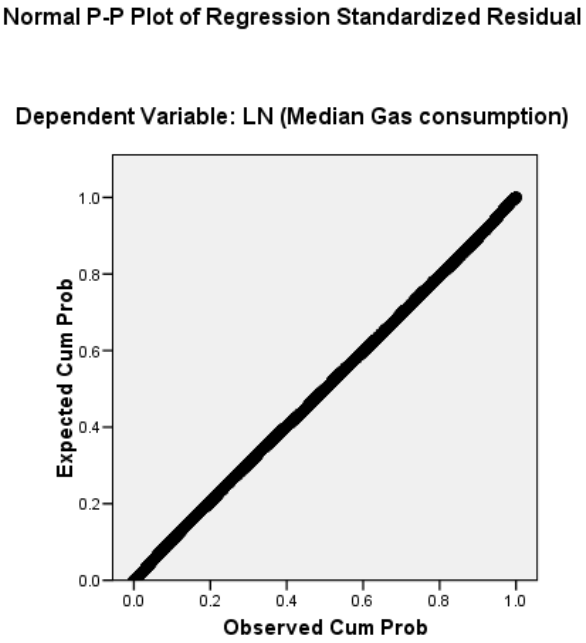
Output 1 - Residuals vs. Expected Median Values



Output 2 - Actual vs. Expected Median Values

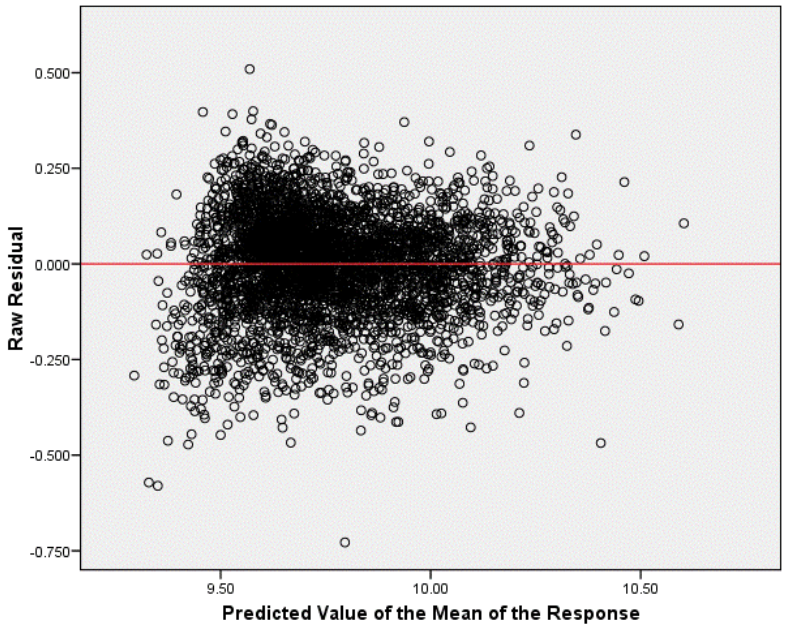


Output 3 – Normal Probability Plot

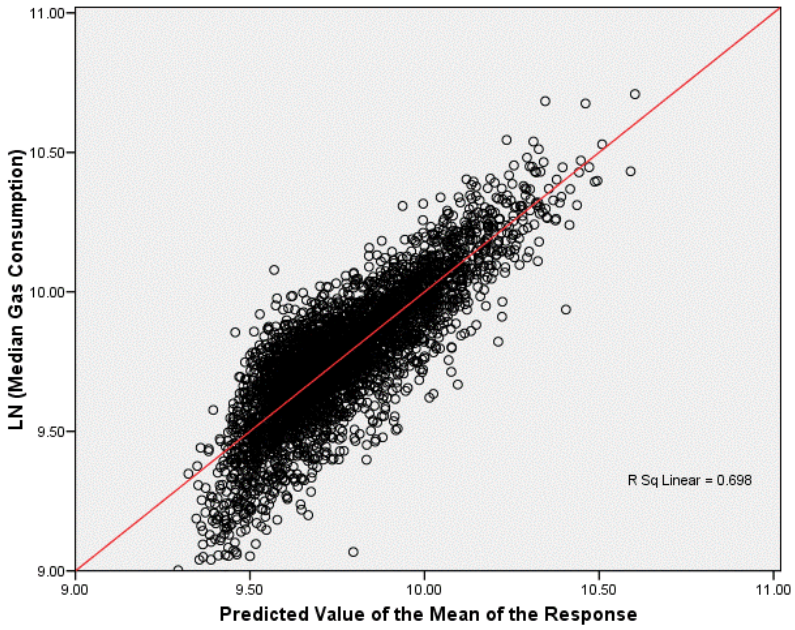


Gas Model - Scotland

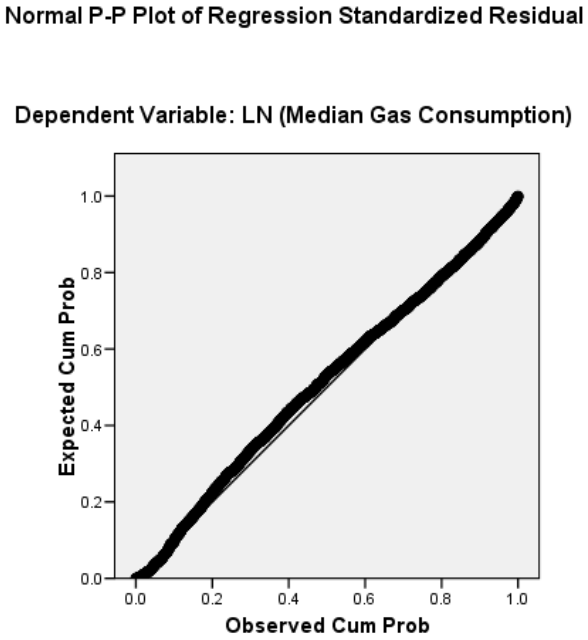
Output 1 - Residuals vs. Expected Median Values



Output 2 - Actual vs. Expected Median Values

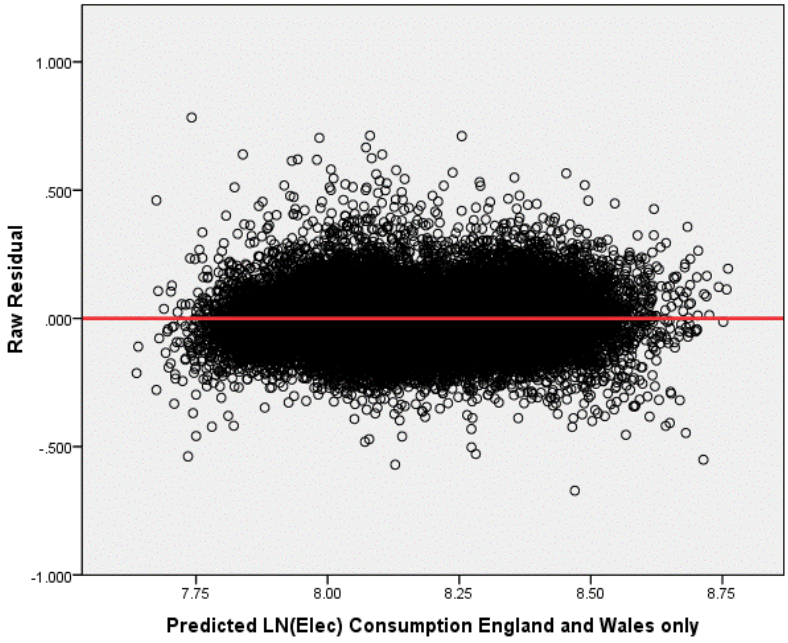


Output 3 – Normal Probability Plot

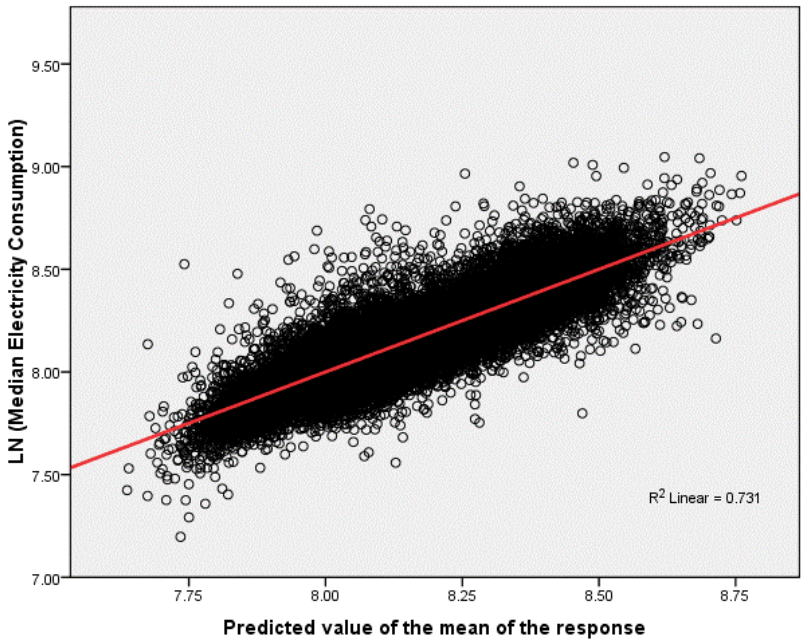


Electricity Model (profile 1 and 2 combined) – England and Wales

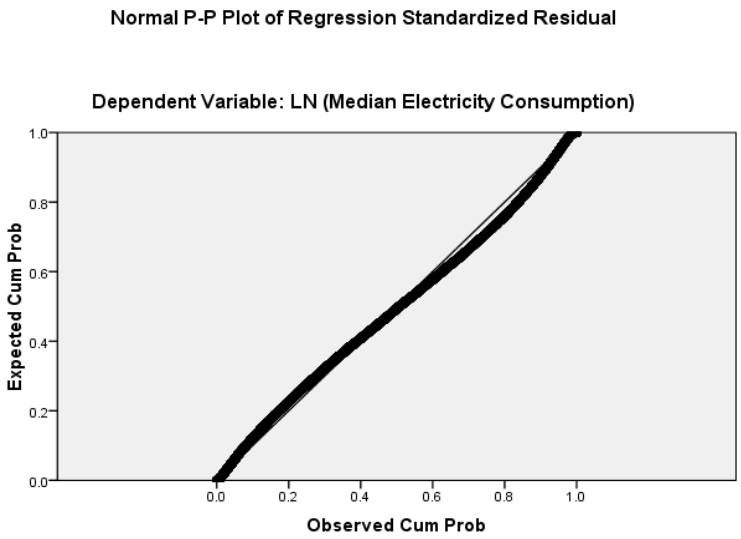
Output 1 - Residuals vs. Expected Median Values



Output 2 - Actual vs. Expected Median Values

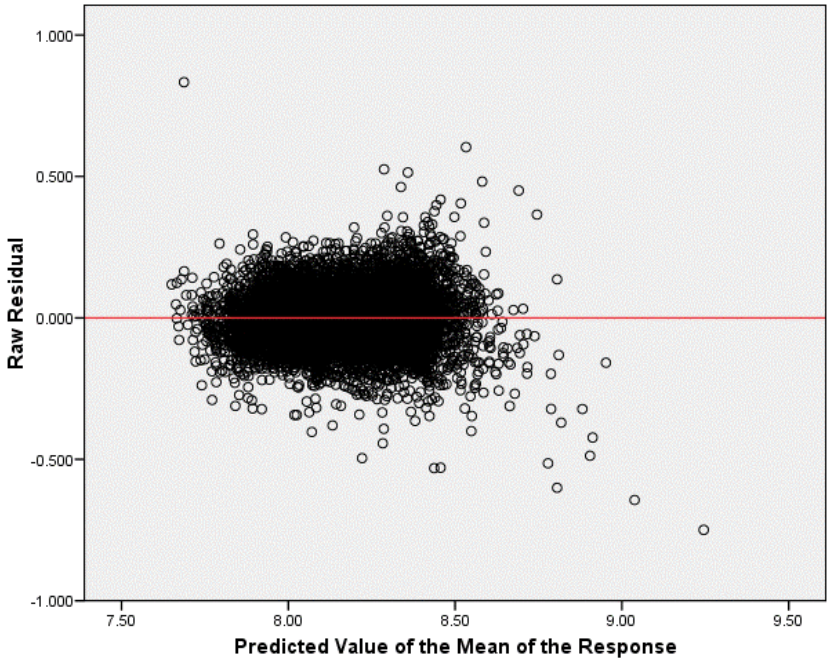


Output 3 – Normal Probability Plot

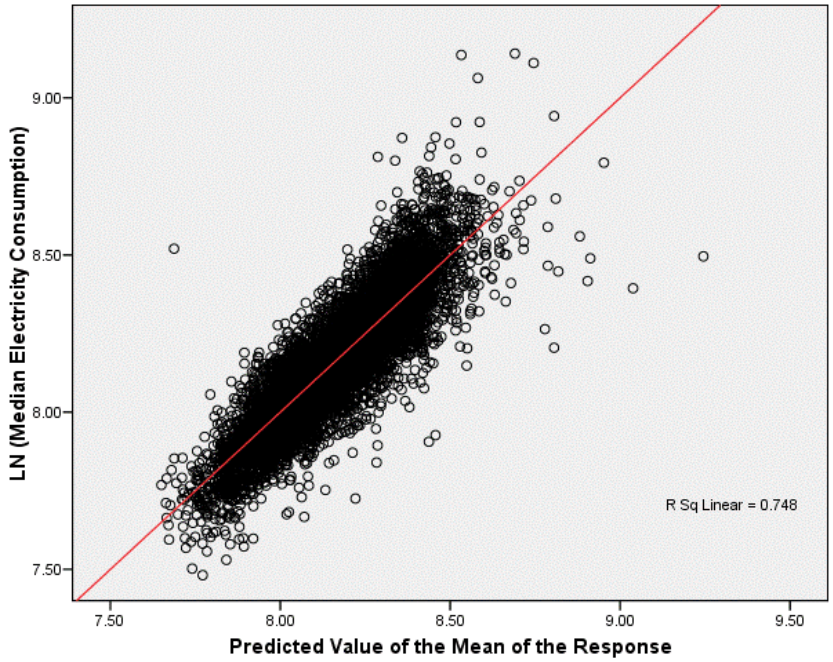


Electricity Model (profile 1 and 2 combined) – Scotland

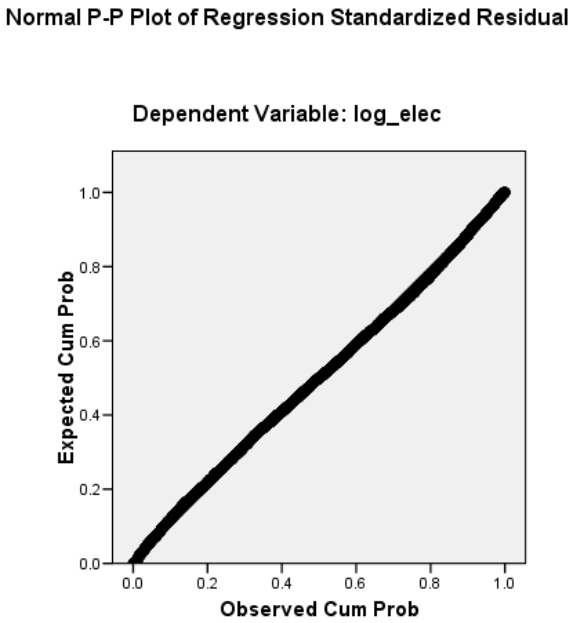
Output 1 - Residuals vs. Expected Median Values



Output 2 - Actual vs. Expected Median Values

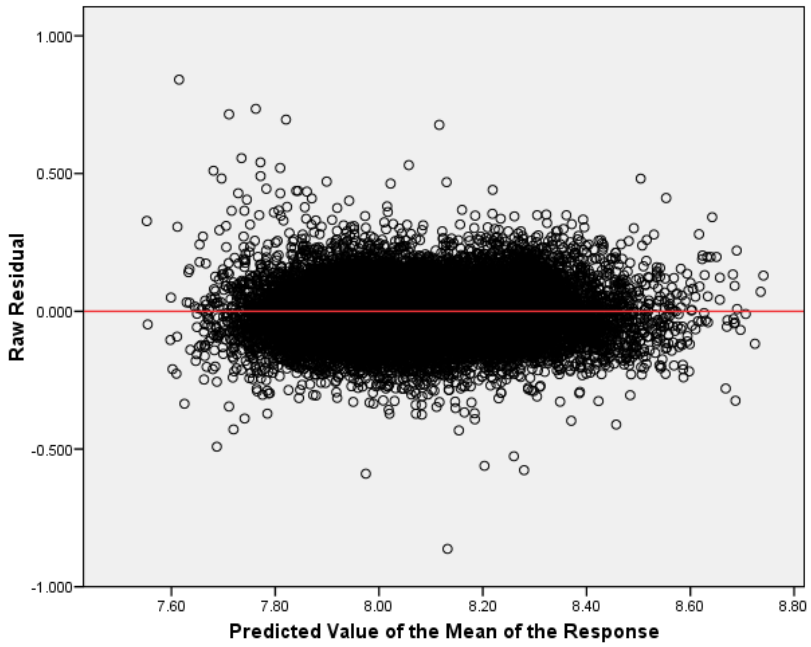


Output 3 – Normal Probability Plot

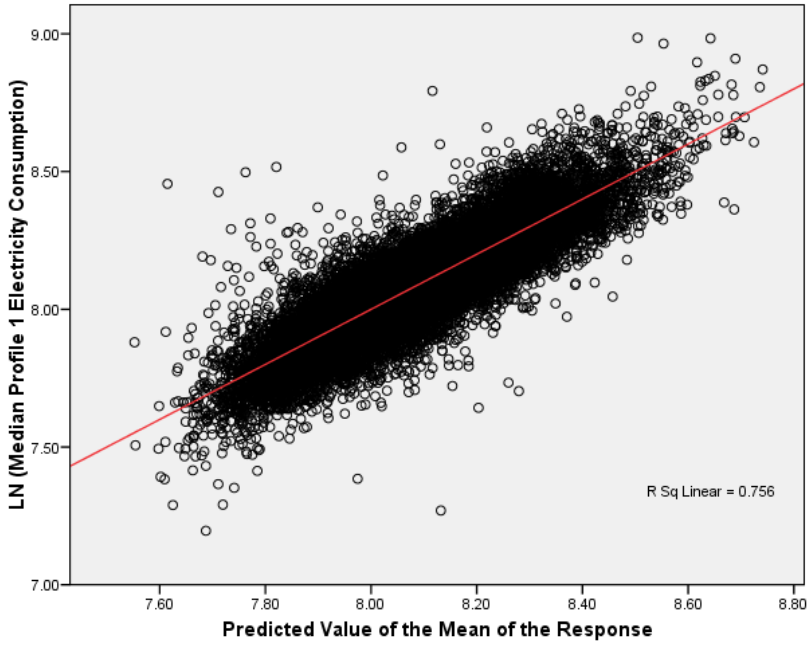


Electricity Model (profile 1) – England and Wales

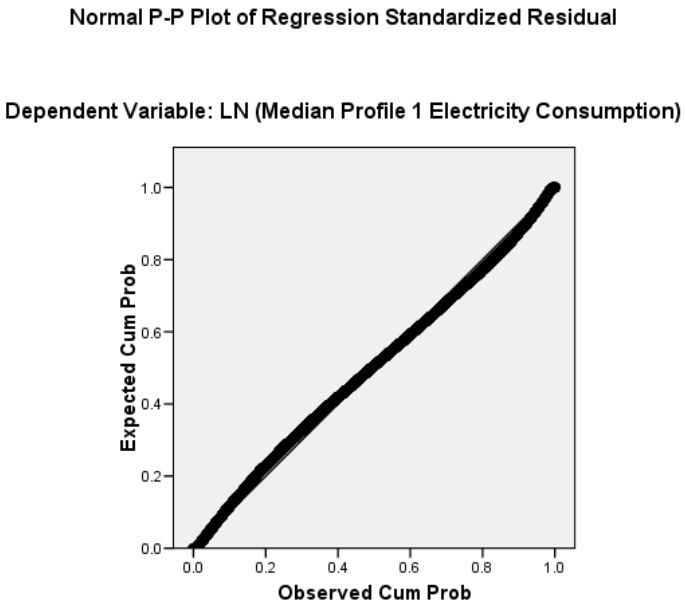
Output 1 - Residuals vs. Expected Median Values



Output 2 - Actual vs. Expected Median Values

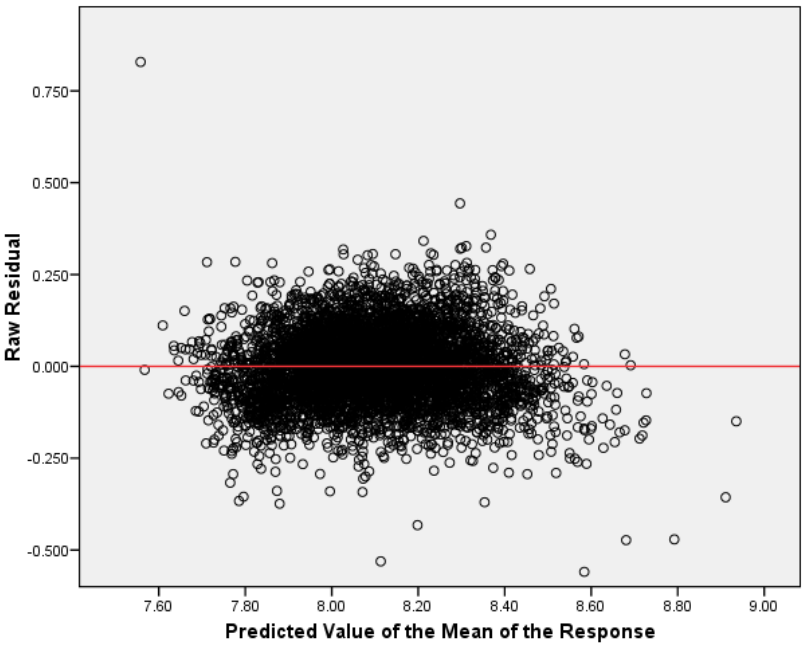


Output 3 – Normal Probability Plot

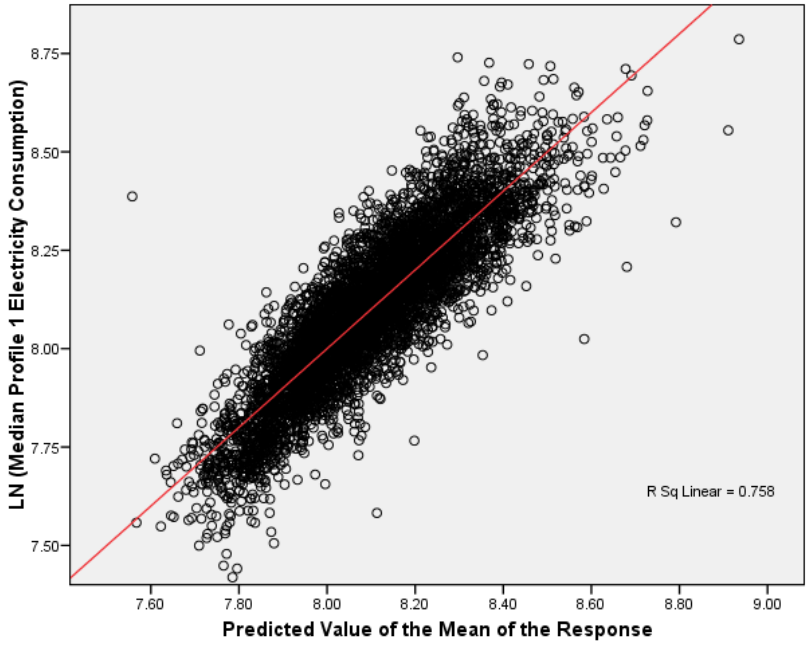


Electricity Model (profile 1) – Scotland

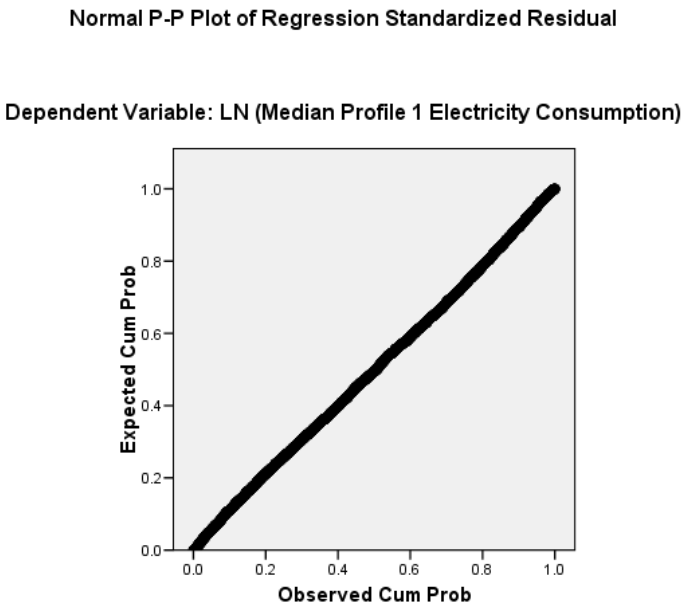
Output 1 - Residuals vs. Expected Median Values



Output 2 - Actual vs. Expected Median Values



Output 3 – Normal Probability Plot



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