Smart Energy Research Lab: Energy tariffs, energy expenditure, and price elasticity of energy use in GB domestic buildings during the 2022/2023 heating season

Citation

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Executive summary

Households in Great Britain were faced with record high energy price increases in 2022. This report analyses:

- how GB household energy tariffs changed in the heating season (defined here as October through to March inclusive) of 2022/2023 compared to the previous year,
- the effect of these price increases on energy usage in terms of price elasticities,
- how gas and electricity expenditures were affected,
- the effectiveness of measures adopted by households to changes their energy use in heating season 2022/2023 to reduce energy expenditure, and
- the impact the Government's Energy Price Guarantee (which set a maximum limit on energy unit costs) had on reducing energy expenditure. Note that during this period the Government also introduced the Energy Bills Support Scheme (EBSS), which provided all households with £400 off their electricity bills. We have not included explicit analysis of the impact of the EBSS in this report, though it is important to note that it is likely to have had a dampening effect on the price response observed i.e. if the EBSS had not been introduced, then energy bills would have been higher, and households may have reduced demand even further, leading to higher price elasticities than observed here.

This report is based on analysis of data from the Smart Energy Research Lab (SERL) Observatory, which consists of smart meter (energy use and tariff data) and contextual data from approximately 13,000 homes that are broadly representative of the GB population in terms of region and relative deprivation of area.

This report builds on and should be read alongside a previous report '*Smart Energy Research Lab: Energy use in GB gas heated domestic buildings during the 2022/2023 heating season*[1]' which analysed the change in energy consumption between winter 2021/2022 and winter 2022/2023 on a temperature adjusted basis for 8,723 households in the SERL Observatory dataset for whom gas is their primary space heating fuel and that had gas and/or electricity data available for both heating seasons. The report found that on a temperature adjusted basis, the reduction in gas usage for these households in heating season 2022/2023 was -7.96 kWh/day per household or -14.90%, and the reduction in

[1] McKenna, E., Few, J., Pullinger, M., Hanmer, C., Zapata-Webborn, E., Elam, S. and Oreszczyn, T., 2023. Smart Energy Research Lab: Energy use in GB gas heated domestic buildings during the 2022/2023 heating season. London: Smart Energy Research Lab, University College London. (SERL Statistical Reports, Vol. 2).

electricity usage was -0.88 kWh/day per household, or a change in percentage terms of -9.09%.

Between March 2022 and March 2023, this report found the energy tariffs for the SERL Observatory participants increased by an average of:

- 78% for electricity standing charges, with direct debit customers facing the largest average increase of 84%,
- 68% for electricity unit costs, with standard credit meters facing the largest average increase of 73.6%,
- 11.7% for gas standing charges, with meters on not on standard variable tariffs facing the largest average increase of 13.8%,
- 164% for gas unit costs, with prepayment meters facing the largest average increase of 168%. Put into context, a 4% difference in the annual gas variable costs given Ofgem typical annual gas consumption values (see below) is about £47/year.

For the SERL Observatory participants, the average (mean) cost associated with the different tariff components during the heating season 2022/2023 was (these have been annualised based on Ofgem's new revised typical annual consumption values of 2700 kWh/year for electricity and 11500 kWh/year for gas):

- Electricity standing charge: £156.7/year
- Electricity variable costs at 2700 kWh/year: £907.1/year
- Gas standing charge: £104.3/year
- Gas variable costs at 11500 kWh/year: £1185.1/year
- Total assuming dual fuel: £2353.2/year. This is £146.8/year lower (-5.9%) than the £2500/year assumed by Ofgem for a typical dual fuel household with typical annual consumption values (as above) on the default cap level with EPG.

The *actual* average (mean) electricity expenditure in heating season 2021/2022 for SERL Observatory participants was £69.4/month. This rose to £111.4/month during the following heating season of 2022/2023, an increase of 60.5%.

Actual average gas expenditure in heating season 2021/2022 was £66.3/month, slightly lower than electricity expenditure, but gas expenditure the following heating season of 2022/2023 was £150.7/month, considerably higher than electricity expenditure at, and an increase of 127%, more than double the increase in electricity expenditure.

Assuming dual fuel the average combined expenditure for heating season 2022/2023 would be £668.4 for electricity and £904.2 for gas, giving a total of £1572.6.

By combining energy expenditure data with income data from a self-reported survey data for the SERL Observatory participants conducted in Jan/Feb 2023, analysis indicates that households with higher income experienced larger increases in both electricity and gas expenditure than households with lower income. The median increase in household electricity expenditure for households in the lowest gross income bands was £23.6/month for households with gross income below £10,000 and £25.0/month for households in the £10,001 to £20,000 band. The increase was around double that for households in the top two gross income bands: £47.8/month and 46.7/month.

The results are similar for gas expenditure. The households in the lowest two income bands had increases in gas expenditures of £48.9/month and £63.3/month, compared to £108.3/month and £117.0/month for households in the top two income bands. Considering the differences in income however, the results suggest that lower income households were likely to have been disproportionately affected by the increases in both electricity and gas expenditure.

Energy expenditure in heating season 2022/2023 was lower than it would have otherwise been due to three factors:

1. households reduced gas and electricity usage, as mentioned previously,
2. the Government's Energy Price Guarantee set maximum gas and electricity unit costs below the Energy Price Cap rates such that 'typical' energy bills would be equal to £2500/year (based on 2900 kWh/year for electricity and 12000 kWh/year for gas), and
3. the Government's Energy Bills Support Scheme which provided all households with £400 off their electricity bills, in monthly payments over the period October 2022 to March 2023 inclusive. As noted previously, the impact of the EBSS is not included in this report's analysis.

Based on counterfactual modelling, the results show that the effect of households reducing electricity usage was a median reduction in household-level electricity expenditure of £6.4/month over the heating season 2022/2023. Median electricity expenditure would have been £98.8/month in heating season 2022/2023 instead of the £90.3/month that was observed. Note that the reason that the median of the distribution of reductions (£6.4/month) does not equal the difference between the medians of the two original distributions (98.8 – 90.3 = £8.5/month) is because these are skewed distributions and the median is not a linear operator, which means that subtracting the medians of two distributions does not equal the median of their differences.

The effect of reducing gas usage was a median reduction in household-level gas expenditure of £18.2/month. Median gas expenditure would have been £160.7/month rather than the £136.9/month that was observed.

Assuming dual fuel the total effect of the median energy use reductions on expenditure for heating season 2022/2023 would have been £38.4 for electricity and £109.2 for gas with a total household-level saving of £147.6.

=The results show that the effect of the Energy Price Guarantee was a median reduction in household-level electricity expenditure of £53.9/month. Median household-level electricity expenditure would have been £146.0/month instead of the £90.3/month that was observed. This is based on the assumption that in the absence of the Energy Price Guarantee, households would have paid the relevant Energy Price Cap level for their region and payment status.

The effect of the Energy Price Guarantee was a median reduction in household-level gas expenditure of £61.1/month. Median household-level electricity expenditure would have been £198.4/month instead of the £136.9/month that was observed.

Assuming dual fuel the total household-level effect of the Energy Price Guarantee using the median reductions in electricity and gas expenditure would have been £323.4 for electricity and £366.6 for gas, with a total household-level saving of £690.

The combined household-level savings due to energy use reduction and the Energy Price Guarantee over heating season 2022/2023, assuming dual fuel and median savings, would have been £837.6. Assuming households also benefitted from the £400 Energy Bill Support Scheme, the saving would have increased to a total of £1237.6 per household over the heating season 2022/2023.

Distributionally, the Energy Price Guarantee benefitted households with higher incomes more than households with lower incomes. This is because the Energy Price Guarantee affected unit costs of gas and electricity, and thus benefitted households in proportion to the volume of energy they used. And as households with higher incomes tend to use more energy than households with lower incomes, this means that they also benefitted more. For households in the lowest two income bands, the median reduction in electricity expenditure due to the EPG was £35.6/month and £38.4/month, while for households in the top two income bands the median reduction was £78.0/month and £90.2/month. For gas expenditure, the median reduction due to the EPG was £40.4/month and £49.4/month for households in the poorest two income bands, and £78.6/month and £96.9/month for households in the top two income bands. Note that the Government also provided support in the form of the Energy Bills Support Scheme's £400 discount on energy bills. This was given to all households equally, and in contrast to the EPG would have benefitted lower income households more in relation to their income.

Introduction

2022 was characterised by large and rapid increases in energy prices. The Energy Price Cap, which sets maximum energy prices for customers on default or standard variable tariffs, increased by 54% for the period from April to September 2022 for 'typical' annual consumption levels, from £1277 per year for a dual fuel customer to £1971[2]. The cap rose a further 80% for the period October to December 2022, and increased again by 21% for the period January to March 2023. However, the Energy Price Guarantee was introduced on 1st October 2022 which limited prices to £2500 for typical annual consumption levels, substantially lower than the cap prices, but still 27% above the summer cap.

GB households responded to these price increases by reducing their energy demand. A previous report '*Smart Energy Research Lab: Energy use in GB gas heated domestic buildings during the 2022/2023 heating season*[3]' analysed the change in energy consumption between winter 2021/2022 and winter 2022/2023 on a temperature adjusted basis for 8,723 households in the SERL Observatory dataset for whom gas is their primary space heating fuel and that had gas and/or electricity data available for both heating seasons. The report found that on a temperature adjusted basis, the reduction in gas usage for these households in heating season 2022/2023 was -7.96 kWh/day per household or -14.90%, and the reduction in electricity usage was -0.88 kWh/day per household, or a change in percentage terms of -9.09%.

The objective of this report is to investigate the *cause* of these changes by analysing actual meter-level energy tariff data in combination with linked meter-level energy usage data from the SERL Observatory dataset. The report is structured as follows:

Longitudinal analysis: we present analysis of observed energy tariffs and how they vary over time. We also specifically compare average energy tariffs over the two heating seasons 2021/2022 and 2022/2023.

Energy expenditure: we analyse actual energy expenditures for the two heating seasons and estimate the change in energy expenditure due to changes in household energy saving actions, and the Energy Price Guarantee.

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[2] Bolton, P., Stewart, I. (2023). Domestic Energy Prices (Report No. CBP-9491). UK Parliament's Commons Library. https://commonslibrary.parliament.uk/research-briefings/cbp-9491/

[3] McKenna, E., Few, J., Pullinger, M., Hanmer, C., Zapata-Webborn, E., Elam, S. and Oreszczyn, T., 2023. Smart Energy Research Lab: Energy use in GB gas heated domestic buildings during the 2022/2023 heating season. London: Smart Energy Research Lab, University College London. (SERL Statistical Reports, Vol. 2).

Price elasticity: we estimate price elasticities of gas and electricity demand using two approaches.

This is followed by an Appendix which describes data quality assurance analysis and methods, including:

Tariff data: this report represents one of the first analyses of SERL Observatory tariff data and as such starts with a data quality assessment of missing data and errors.

Payment status: energy prices are affected by payment status (direct debit, standard credit, prepayment) however we do not directly observe payment status from meter data. We can however estimate payment status from responses to a survey we conducted in Q1 2023 and by comparing energy tariffs with the levels set by the Energy Price Cap or Energy Price Guarantee.

Comparison of tariffs data with published levels set by the Energy Price Cap and Energy Price Guarantee: we report numbers of meters with tariffs that match levels of the Energy Price Cap or Energy Price Guarantee. For meters that do not match, we analyse the difference in observed energy tariffs with the Cap/Guarantee and how this varies over time, which reveals how much more or less the energy tariffs for these households are compared to the Cap/Guarantee levels.

Meters with tariffs that do not change: we report numbers of meters with tariffs that are unchanged from heating season 2021/2022 to heating season 2022/2023.

Tariffs and VAT: we do not directly observe from tariff data whether tariffs include VAT or not. By comparing tariff data with Cap/Guarantee levels, we can however estimate the proportion of meters with tariffs that include VAT or not.

Missing tariff data imputation: we describe and present the results of the rules used to impute missing tariff data.

In this report we analyse tariff data that is held on the smart meters of the participants of the SERL Observatory. However, it is important to note that this tariff data is *not* the tariff data that energy suppliers use for billing. The tariff data that is stored on meters depends on suppliers taking the tariff data used to bill consumers and updating the tariff data on the meter. This means any issues observed with tariff data reported here should not be taken as evidence that there are any issues with billing.

The accuracy of the tariff data on smart meters that we access is therefore fundamentally reliant on energy suppliers promptly and accurately updating the tariff data on the smart meters of their customers. One of the consequences of this is that we are unable to distinguish between a situation where a customer is on a fixed tariff that is therefore unchanging for a period of time, from a situation where a customer is on a variable tariff but their energy supplier is not updating the tariff on their meter. We access no other contextual data on the meter relating to tariffs that could clarify this situation e.g. the name of the tariff, or the energy supplier.

Variation in energy prices over time

The following shows how energy prices varied over time, using the tariff data from SERL Observatory smart meters. The following plot shows means and standard deviations, and this is followed by tables with the same information. These include counts which have been rounded to the nearest 10.

All figures show a slight initial decrease in price from October 2021 to November 2021. October 2021 was characterised by a complete lack of tariff data collected from SERL Observatory meters, and this change is likely due to this step change in data availability and the resulting effect on imputed tariff prices that results (see the Appendix for information about missing tariff data and how this was imputed).

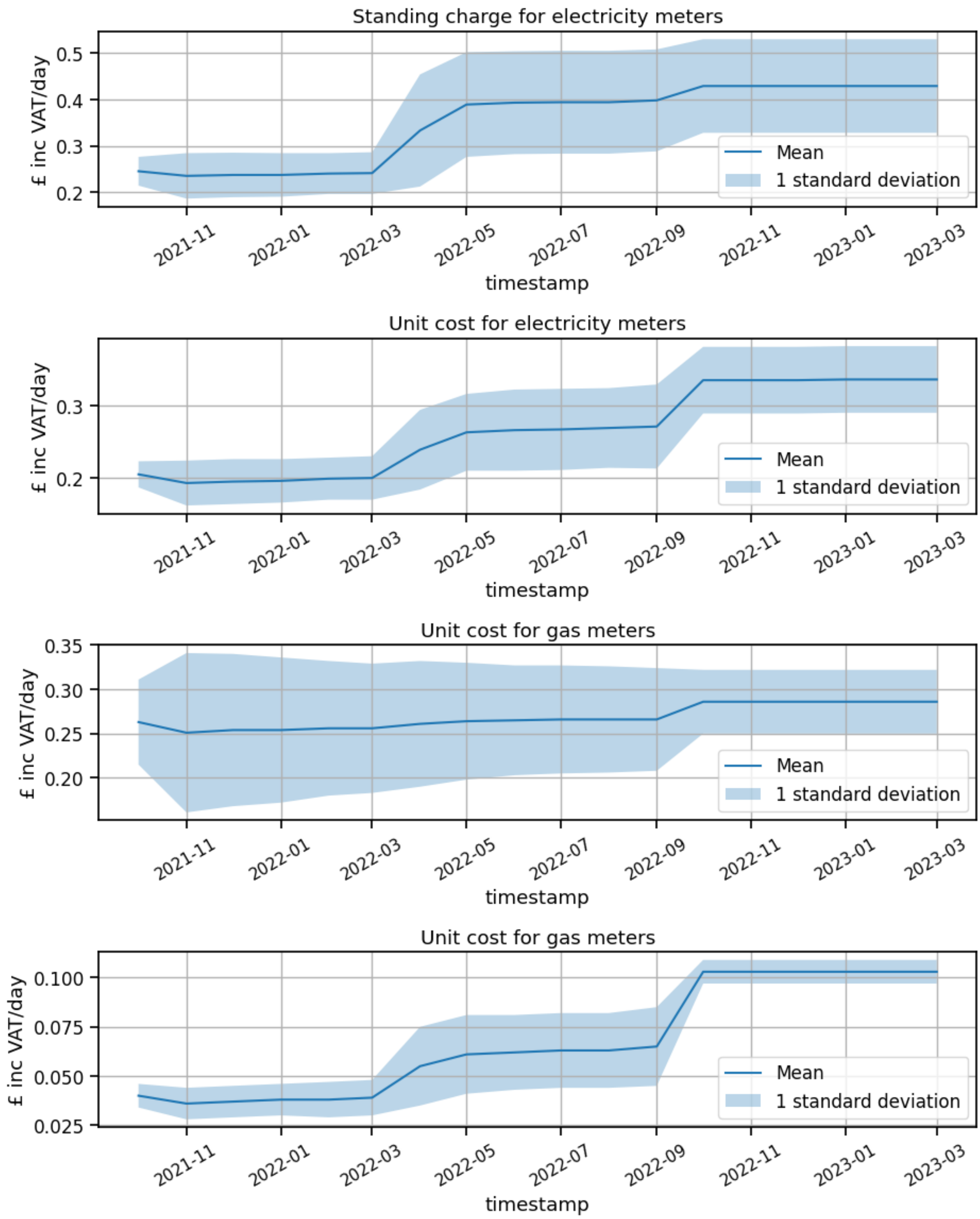

Figure 1. Variation over time of electricity and gas standing charges and unit costs. Lines show the mean, and shaded region shows the standard deviation of the underlying distributions. For underlying data see: mean_tariff_variables_over_time_no_breakdown.csv

Electricity standing charge

The results show the mean electricity standing charge staying steady around £0.24 per day throughout the heating season of 2021/2022, then rising from April 2022 when the Energy Price Cap levels changed to £0.39 per day, an increase of approximately 66%. The mean standing charge stayed at this level until September 2022, when the Energy Price Cap increased again, to £0.43 per day, an increase of 10%, staying at this level for the rest of the 2022/2023 heating season. The year-to-date increase from March 2022 to March 2023 was 78%.

Table 1. Mean and standard deviation of electricity standing charge (£/day inc VAT) by month along with sample size (rounded_n).

month	meter_type	variable	mean_value	std_dev_value	rounded_n
2021-10	electricity	standing charge	0.245	0.031	12140
2021-11	electricity	standing charge	0.235	0.049	12140
2021-12	electricity	standing charge	0.237	0.048	12140
2022-01	electricity	standing charge	0.237	0.047	12140
2022-02	electricity	standing charge	0.24	0.044	12140
2022-03	electricity	standing charge	0.241	0.045	12140
2022-04	electricity	standing charge	0.333	0.121	12140
2022-05	electricity	standing charge	0.389	0.113	12140
2022-06	electricity	standing charge	0.393	0.111	12140
2022-07	electricity	standing charge	0.394	0.111	12140
2022-08	electricity	standing charge	0.394	0.111	12140
2022-09	electricity	standing charge	0.398	0.11	12140
2022-10	electricity	standing charge	0.429	0.101	12140
2022-11	electricity	standing charge	0.429	0.101	12140
2022-12	electricity	standing charge	0.429	0.101	12140
2023-01	electricity	standing charge	0.429	0.101	12140
2023-02	electricity	standing charge	0.429	0.101	12140
2023-03	electricity	standing charge	0.429	0.101	12140

Electricity unit cost

The mean electricity unit cost stayed relatively constant through the 2021/2022 heating season at around £0.2 per kWh. When the Energy Price Cap changed in April 2022 it rose to around to around £0.27 per kWh, an increase of around 35%. After September 2022 when the Energy Price Guarantee came into affect, it rose to £0.335 per kWh, an increase of 24%, staying at this level for the rest of the heating season of 2022/2023. The year-to-date increase from March 2022 to March 2023 was 68%.

Table 2. Mean and standard deviation of electricity unit cost (£/kWh inc VAT) by month along with sample size (rounded_n).

month	meter_type	variable	mean_value	std_dev_value	rounded_n
2021-10	electricity	unit cost	0.205	0.018	12200
2021-11	electricity	unit cost	0.193	0.031	12200
2021-12	electricity	unit cost	0.195	0.031	12200
2022-01	electricity	unit cost	0.196	0.03	12200
2022-02	electricity	unit cost	0.199	0.029	12200
2022-03	electricity	unit cost	0.2	0.03	12200
2022-04	electricity	unit cost	0.239	0.055	12200
2022-05	electricity	unit cost	0.263	0.053	12200
2022-06	electricity	unit cost	0.266	0.056	12200
2022-07	electricity	unit cost	0.267	0.056	12200
2022-08	electricity	unit cost	0.269	0.055	12200
2022-09	electricity	unit cost	0.271	0.058	12200
2022-10	electricity	unit cost	0.335	0.046	12200
2022-11	electricity	unit cost	0.335	0.046	12200
2022-12	electricity	unit cost	0.335	0.046	12200
2023-01	electricity	unit cost	0.336	0.046	12200
2023-02	electricity	unit cost	0.336	0.046	12200
2023-03	electricity	unit cost	0.336	0.046	12200

Gas standing charge

The mean gas standing charge stayed reasonably level around £0.256 per day throughout the 2021/2022 heating season. When the Energy Price Cap changed in April 2022, this increased to £0.266, an increase of around 4%. This remained stable until the Energy Price Cap changed again in October 2022, increasing to £0.286 per day, an increase of 7.5%. The year-to-date change from March 2022 to March 2023 was 11.7%.

Table 3. Mean and standard deviation of gas standing charge (£/day inc VAT) by month along with sample size (rounded_n).

month	meter_type	variable	mean_value	std_dev_value	rounded_n
2021-10	gas	standing charge	0.263	0.048	9550
2021-11	gas	standing charge	0.251	0.09	9550
2021-12	gas	standing charge	0.254	0.086	9550
2022-01	gas	standing charge	0.254	0.082	9550
2022-02	gas	standing charge	0.256	0.076	9550
2022-03	gas	standing charge	0.256	0.073	9550
2022-04	gas	standing charge	0.261	0.071	9550
2022-05	gas	standing charge	0.264	0.066	9550
2022-06	gas	standing charge	0.265	0.062	9550
2022-07	gas	standing charge	0.266	0.061	9550
2022-08	gas	standing charge	0.266	0.06	9550
2022-09	gas	standing charge	0.266	0.058	9550
2022-10	gas	standing charge	0.286	0.036	9550
2022-11	gas	standing charge	0.286	0.036	9550
2022-12	gas	standing charge	0.286	0.036	9550
2023-01	gas	standing charge	0.286	0.036	9550
2023-02	gas	standing charge	0.286	0.036	9550
2023-03	gas	standing charge	0.286	0.036	9550

Gas unit cost

The mean gas unit cost was relatively stable at around £0.038 per kWh throughout the 2021/2022 heating season. When the Energy Price Cap changed in April 2022, it increased to around £0.063 per kWh, an increase of around 65%. It increased again in October 2022 due to the change to the Energy Price Guarantee to £0.103 per kWh, an increase of 63%. The year-to-date increase from March 2022 to March 2023 was 164%.

Table 4. Mean and standard deviation of gas unit cost (£/kWh inc VAT) by month along with sample size (rounded_n).

month	meter_type	variable	mean_value	std_dev_value	rounded_n
2021-10	gas	unit cost	0.04	0.006	9750
2021-11	gas	unit cost	0.036	0.008	9750
2021-12	gas	unit cost	0.037	0.008	9750
2022-01	gas	unit cost	0.038	0.008	9750
2022-02	gas	unit cost	0.038	0.009	9750
2022-03	gas	unit cost	0.039	0.009	9750
2022-04	gas	unit cost	0.055	0.02	9750
2022-05	gas	unit cost	0.061	0.02	9750
2022-06	gas	unit cost	0.062	0.019	9750
2022-07	gas	unit cost	0.063	0.019	9750
2022-08	gas	unit cost	0.063	0.019	9750
2022-09	gas	unit cost	0.065	0.02	9750
2022-10	gas	unit cost	0.103	0.006	9750
2022-11	gas	unit cost	0.103	0.006	9750
2022-12	gas	unit cost	0.103	0.006	9750
2023-01	gas	unit cost	0.103	0.006	9750
2023-02	gas	unit cost	0.103	0.006	9750
2023-03	gas	unit cost	0.103	0.006	9750

The following sections show how energy prices varied over time for different household types segmented by region, and (imputed) payment status. The figures all show means. Underlying data tables include standard deviations, standard errors and 95% confidence intervals for the mean. Counts are included, and these have all been rounded to the nearest 10. Statistics for any case where the resulting cell is less than or equal to 10 have been suppressed.

Region

Electricity standing charge

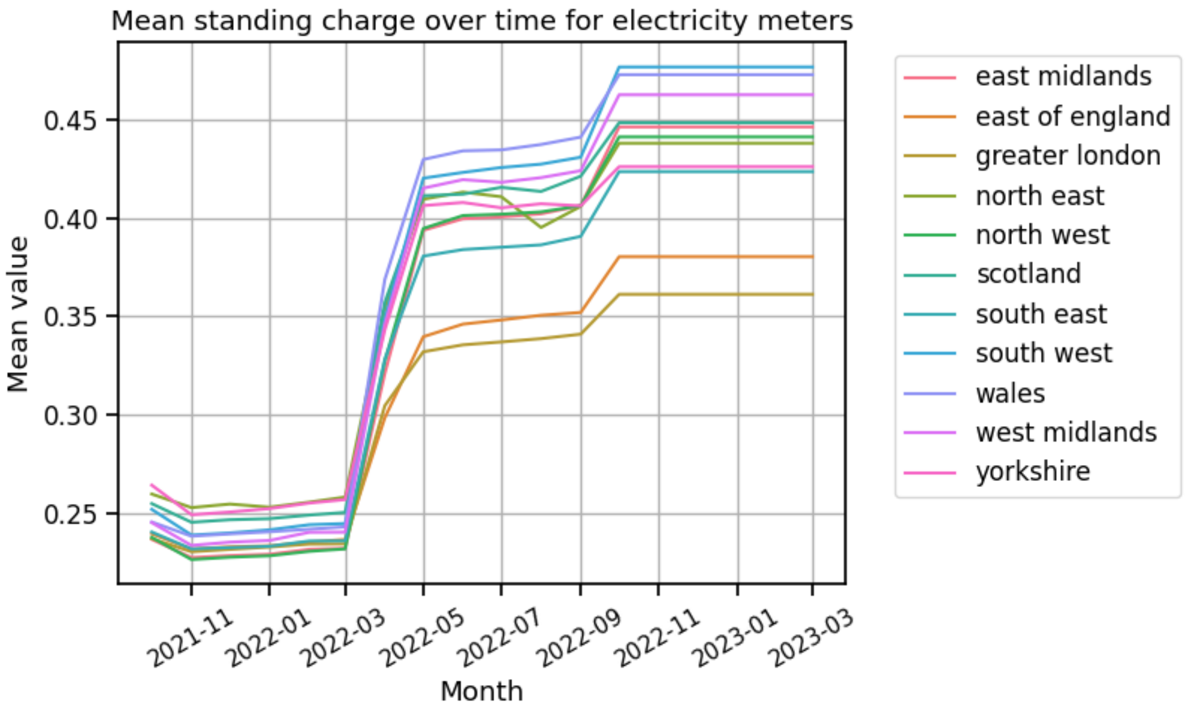

Figure 2. Variation over time in mean electricity standing charge by region. For underlying data see: tariff_timeseries_mean_variable_by_region_electricity_standing charge.csv

From October 2021 to March 2022, the region with the lowest mean electricity standing charge was the North West, with a value of approximately £0.23 per day. The region with the highest mean electricity standing charge was the North East, with a value of approximately £0.26 per day.

For the following heating season, from October 2022 to March 2023, the region with the lowest mean electricity standing charge was Greater London, with a value of approximately £0.36 per day. The region with the highest mean electricity standing charge was the South West, with a value of approximately £0.48 per day. This is slightly lower than the Energy Price Cap standing charge for this region and period for ‘other’ payment status which was £0.501 per day.

The region with the highest percentage increase in mean electricity standing charge from March 2022 to March 2023 was the South West, with an increase of approximately 95%.

Electricity unit cost

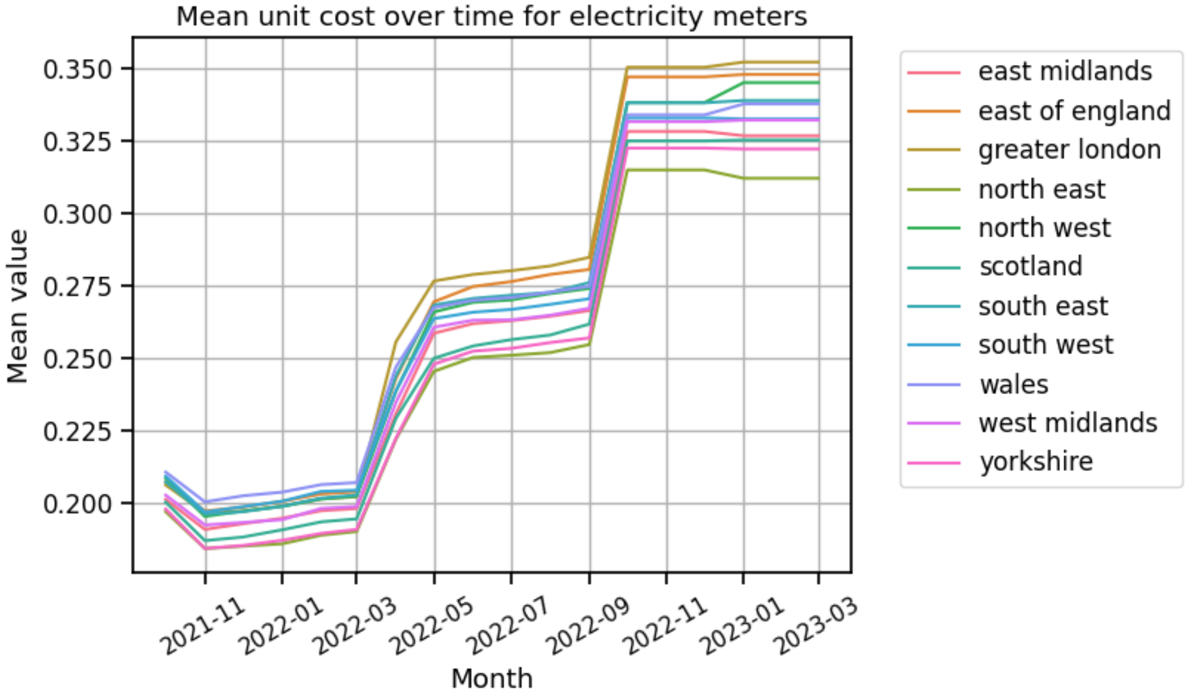

Figure 3. Variation over time in mean electricity unit cost by region. For underlying data see: tariff_timeseries_mean_variable_by_region_electricity_unit cost.csv

From October 2021 to March 2022, the region with the lowest mean electricity unit cost was the North East, with a value of approximately £0.189 per kWh. The region with the highest mean electricity unit cost was Wales, with a value of approximately £0.205 per kWh.

For the following heating season, from October 2022 to March 2023, the region with the lowest mean electricity unit cost was the North East, with a value of approximately £0.313 per kWh. The region with the highest mean electricity standing charge was the Greater London, with a value of approximately £0.351 per kWh. This is slightly lower than the Energy Price Guarantee unit cost for this region and period for 'other' payment status which was £0.361 per kWh.

The region with the highest percentage increase in mean electricity unit cost from March 2022 to March 2023 was Greater London, with an increase of approximately 74%.

Gas standing charge

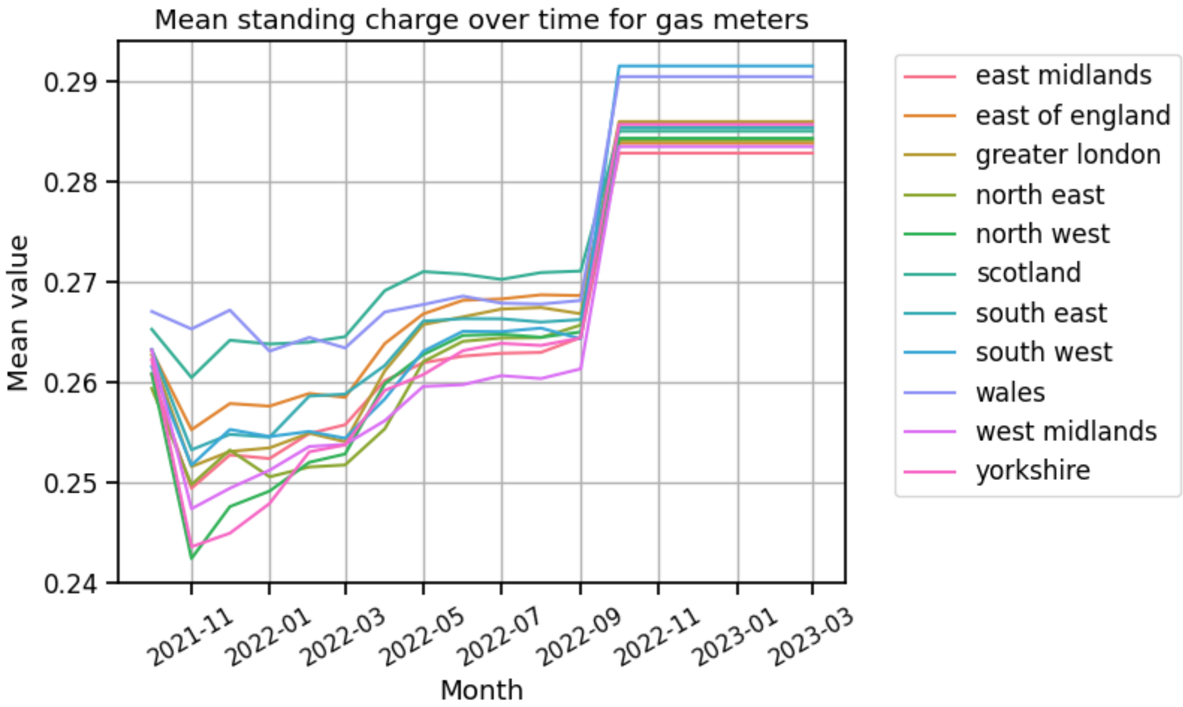

Figure 4. Variation over time of mean gas standing charge by region. For underlying data see: tariff_timeseries_mean_variable_by_region_gas_standing charge.csv

From October 2021 to March 2022, the region with the lowest mean gas standing charge was the North West, with a value of approximately £0.251 per day. The region with the highest mean gas standing charge was Wales, with a value of approximately £0.265 per day.

For the following heating season, from October 2022 to March 2023, the region with the lowest mean gas standing charge was East Midlands, with a value of approximately £0.283 per day. The region with the highest mean gas standing charge was the South West, with a value of approximately £0.292 per day. This is slightly higher than the Energy Price Cap standing charge for the Southern Western region and period for ‘other’ payment status which was £0.285 per day. Ofgem groups payment statuses or methods into standard credit (when consumers pay for their energy after they have used it upon receipt of a bill from their energy supplier), prepayment (where consumers pay for their energy up front), and ‘other’ (which predominantly refers to consumers with direct debit payments that are usually regular fixed payments that are taken from their account every month).

The region with the highest percentage increase in mean gas standing charge from March 2022 to March 2023 was the South West, with an increase of approximately 14.6%.

Gas unit cost

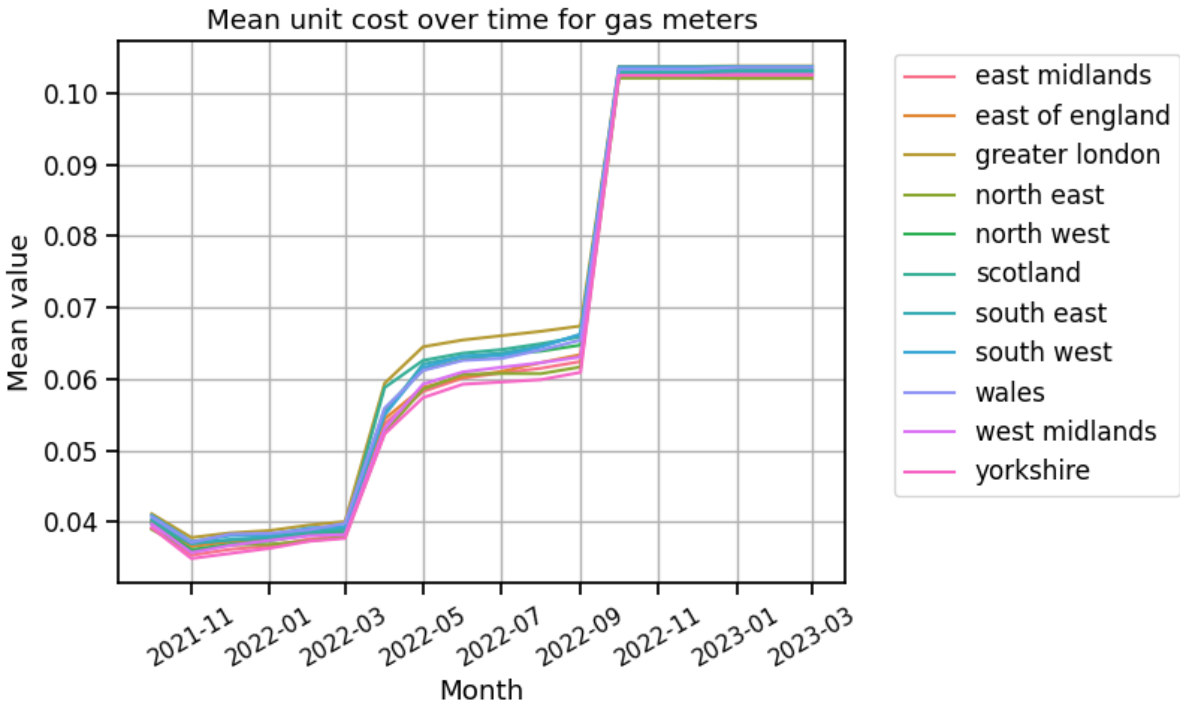

Figure 5. Variation over time in mean gas unit cost by region. For underlying data see: tariff_timeseries_mean_variable_by_region_gas_unit cost.csv

From October 2021 to March 2022, the region with the lowest mean gas unit cost was Yorkshire, with a value of approximately 3.68p per kWh. The region with the highest mean gas unit cost was Greater London, with a value of approximately 3.93p per kWh.

For the following heating season, from October 2022 to March 2023, the region with the lowest mean gas unit cost was the North East, with a value of approximately 10.21p per kWh. The region with the highest mean gas standing charge was the Greater London, with a value of approximately 10.38p per kWh. This is lower than the Energy Price Guarantee unit cost for the London region and period for ‘other’ payment status which was 10.5p per kWh inc VAT.

The region with the highest percentage increase in mean gas unit cost from March 2022 to March 2023 was Yorkshire, with an increase of approximately 172%.

Payment status

The following figures show variation over time in mean tariff components by payment status. There are four principal categories: other, prepayment, standard credit, and ‘not prepayment as assumed fixed tariff’. The first three correspond to meters with tariffs that matched the Energy Price Cap or Energy Price Guarantee, thus allowed payment status to be inferred, or where tariff data was missing and this was imputed using using the appropriate Cap /

Guarantee level if payment status was available via the cost-of-living crisis survey or else assuming ‘other’ payment status. Therefore, the variation in tariff components displayed in the following figures for these first three categories should be identical to the changes to the published Cap / Guarantee levels.

The fourth category ‘not prepayment as assumed fixed tariff’ corresponds to all remaining meters with tariffs that did not match the Cap / Guarantee. As indicated in previous results, the following figures reveal that these meters had tariffs with lower prices than the Cap / Guarantee, which we assume here corresponds to meters on fixed tariffs.

Electricity standing charge

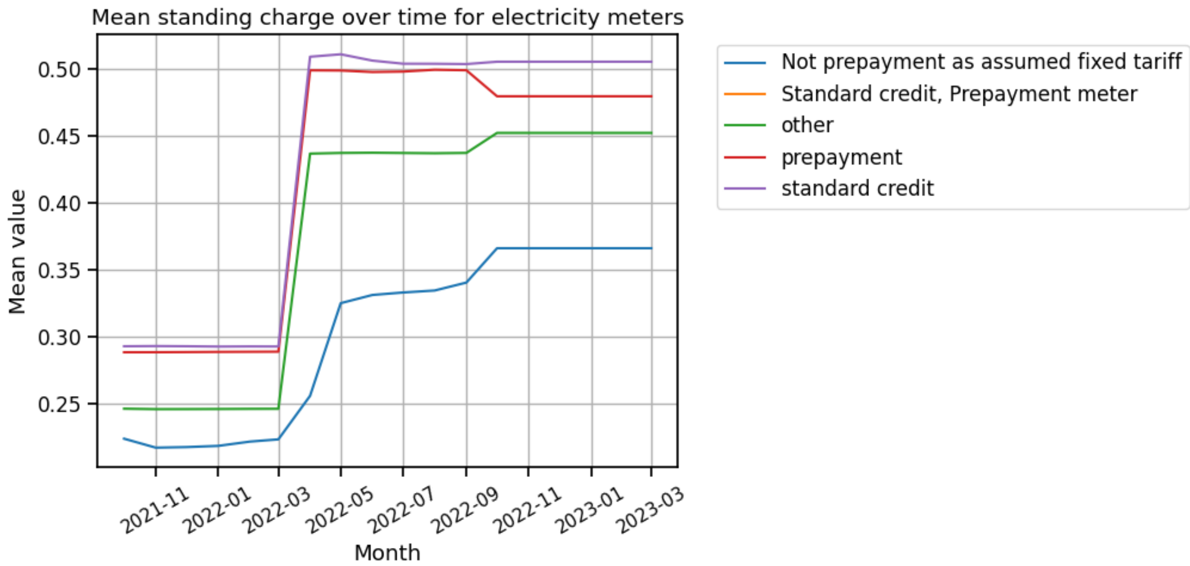

Figure 6. Variation over time of mean electricity standing charge by payment status. Note that a line for ‘Standard credit, Prepayment meter’ does not appear on the figure because the numbers are all zero. For underlying data see: tariff_timeseries_mean_variable_by_imputed_payment_status_electricity_standing charge.csv

For the period October 2021 to March 2022, standard credit meters had the highest electricity standing charge of £0.293 per day, followed by prepayment £0.289 per day, then other payment status £0.246 per day, and meters on fixed tariffs had the lowest at £0.22 per day.

For the period October 2022 to March 2023, standard credit meters had the highest electricity standing charge of £0.506 per day, followed by prepayment at £0.48 per day, then other (direct debit) at £0.453 per day, and fixed tariffs at £0.366 per day.

Other (direct debit) meters experienced the biggest increase in electricity standing charge from March 2022 to March 2023 at 84%.

Electricity unit cost

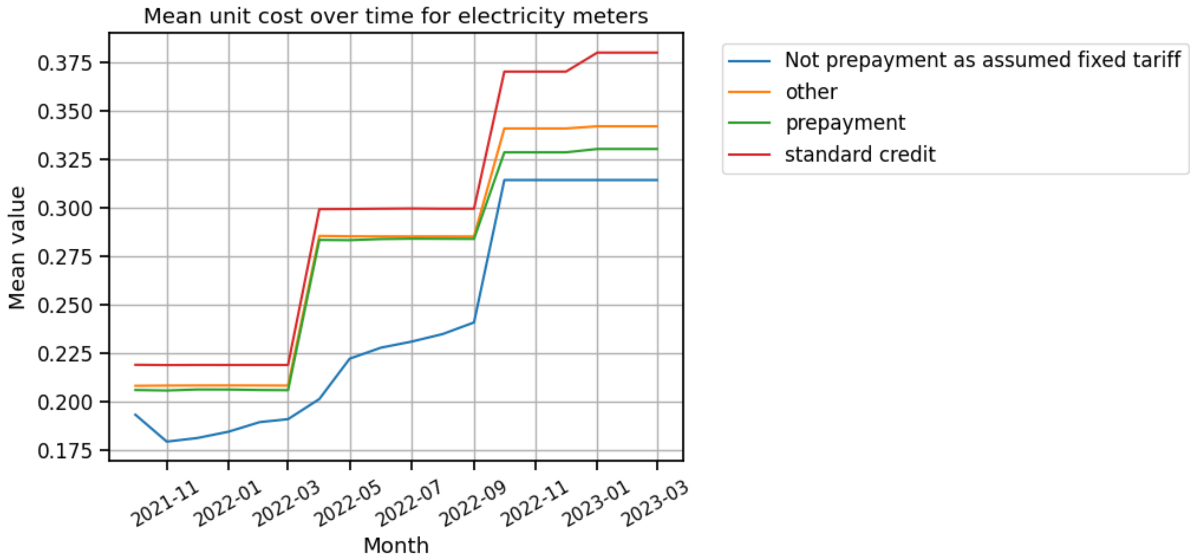

Figure 7. Variation over time of mean electricity unit cost by payment status. For underlying data see: tariff_timeseries_mean_variable_by_imputed_payment_status_electricity_unit cost.csv

For the period October 2021 to March 2022, standard credit meters had the highest electricity unit cost of £0.219 per kWh, followed by other (direct debit) at £0.208 per kWh, then prepayment at £0.206 per kWh, and meters on fixed tariffs had the lowest at £0.186 per kWh.

For the period October 2022 to March 2023, standard credit meters had the highest electricity unit cost of £0.375 per kWh, then other (direct debit) at £0.342 per kWh, followed by prepayment at £0.330 per kWh, and fixed tariffs at £0.314 per kWh.

Standard credit meters experienced the biggest increase in electricity unit cost from March 2022 to March 2023 at 73.6%.

Gas standing charge

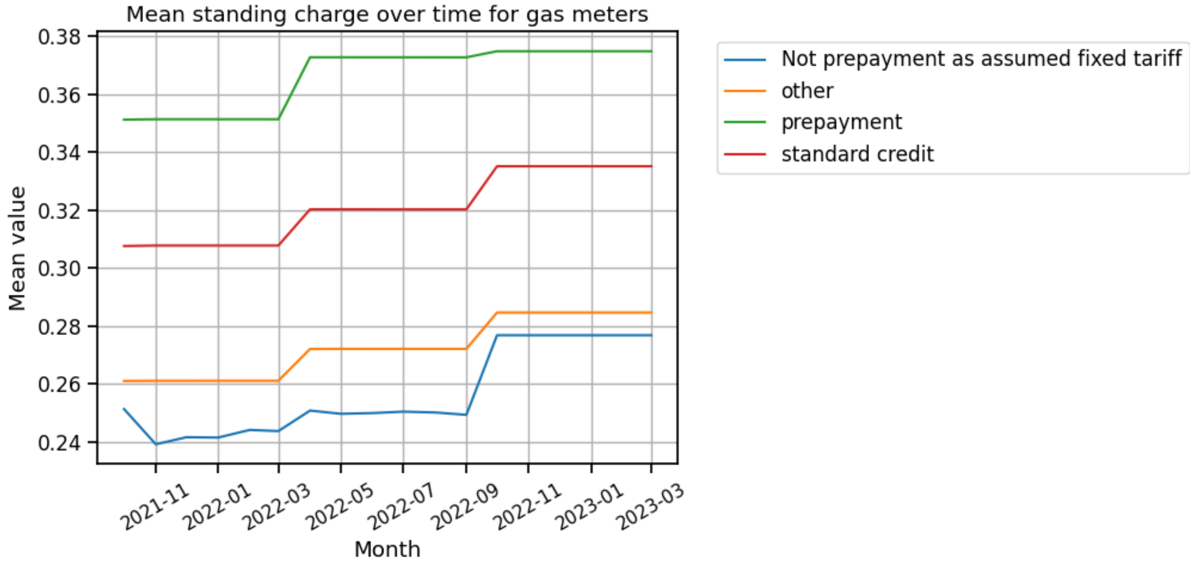

Figure 8. Variation over time of mean gas standing charge by payment status. For underlying data see: tariff_timeseries_mean_variable_by_imputed_payment_status_gas_standing charge.csv

For the period October 2021 to March 2022, prepayment meters had the highest gas standing charge of £0.351 per day, followed by standard credit £0.308 per day, then other payment status £0.261 per day, and meters on fixed tariffs had the lowest at £0.244 per day.

For the period October 2022 to March 2023, prepayment meters had the highest gas standing charge of £0.375 per day, followed by standard credit at £0.335 per day, then other (direct debit) at £0.285 per day, and fixed tariffs at £0.277 per day.

Meters on fixed tariffs experienced the biggest increase in gas standing charge from March 2022 to March 2023 at 13.8%.

Gas unit cost

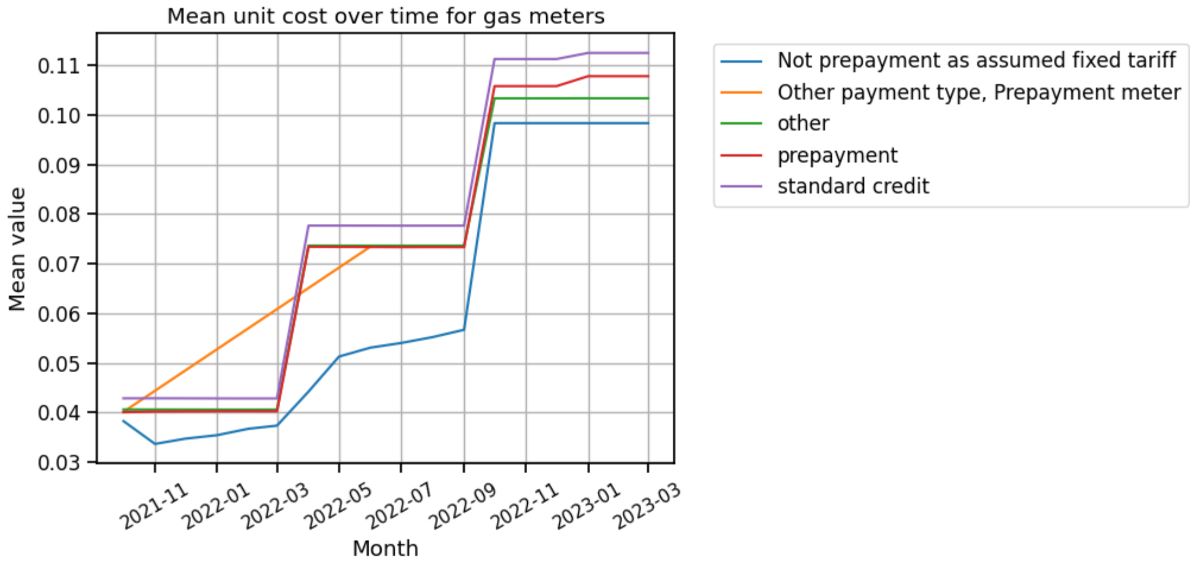

Figure 9. Variation over time of mean gas unit cost by payment status. For underlying data see: tariff_timeseries_mean_variable_by_imputed_payment_status_gas_unit cost.csv

For the period October 2021 to March 2022, standard credit meters had the highest gas unit cost of £0.043 per kWh, followed by other (direct debit) at £0.041 per kWh, then prepayment at £0.0.040 per kWh, and meters on fixed tariffs had the lowest at £0.036 per kWh.

For the period October 2022 to March 2023, standard credit meters had the highest gas unit cost of £0.112 per kWh, followed by prepayment at £0.107 per kWh, then other (direct debit) at £0.103 per kWh, and fixed tariffs at £0.098 per kWh.

Prepayment meters experienced the biggest increase in gas unit cost from March 2022 to March 2023 at 168%.

A small number (~30) meters are in an 'other payment type, prepayment meter' category, indicating that matching their tariffs to the Energy Price Cap levels resulted in multiple possible payment statuses.

Change in energy prices between heating season 2021/2022 and 2022/2023

The following plots in this section show distributions of the average monthly tariff variables for each meter for the two heating seasons. Each meter therefore contributes a single observation to a distribution. The monthly tariff values are converted to annual values using 365.25 days for standing charge and the Ofgem typical annual consumption values of 2700kWh/year for electricity and 11500kWh/year for gas. Counts are based on values rounded to the nearest 10 to avoid statistical disclosure.

Vertical lines are used to indicate the means of the distributions, as well as the mean value assuming all meters were on the Energy Price Cap for their relevant region and payment status.

Electricity standing charge

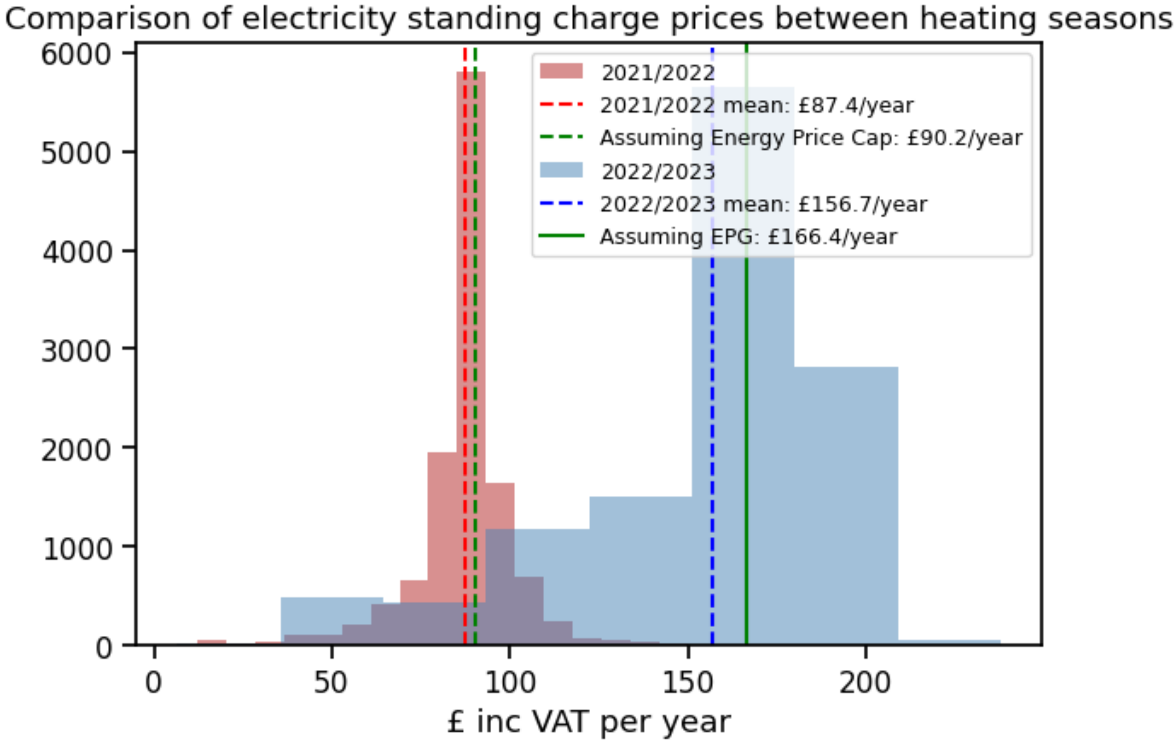

Figure 10. Histograms showing distribution of average electricity standing charges on meters for heating season 2021/2022 and heating season 2022/2023. For underlying data see: hist_compare_two_seasons_electricity_standing charge.csv.

For heating season 2021/2022 the average electricity standing charge was £87.4/year, slightly lower than the average of £90.2/year if all meters were on the Energy Price Cap due to meters on lower rate fixed tariffs. For heating season 2022/2023 the average increased to £156.7/year, which is lower compared to the average of £166.4/year if all meters were on the Energy Price Guarantee. The average increase between the seasons was £69.4/year (see Figure 14 below), an increase of 79.4%.

Electricity unit cost

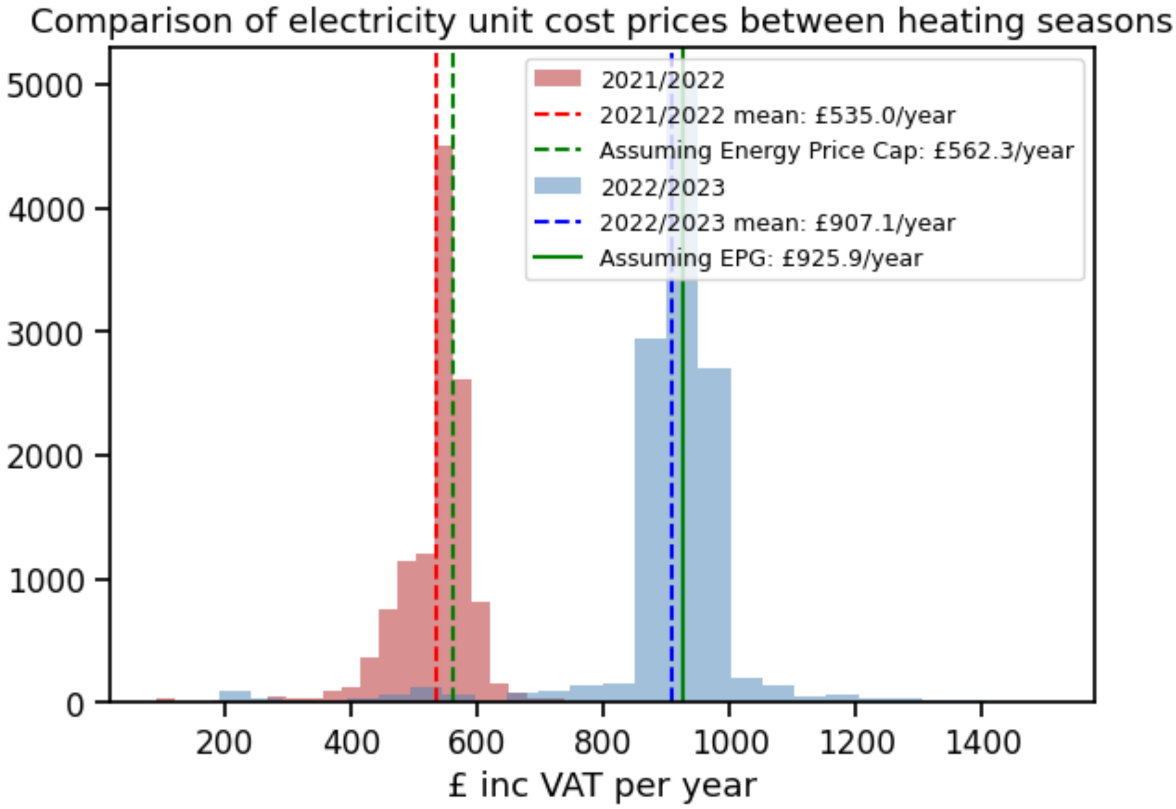

Figure 11. Histograms showing distribution of average electricity unit costs on meters for heating season 2021/2022 and heating season 2022/2023. For underlying data see: hist_compare_two_seasons_electricity_unit cost.csv

For heating season 2021/2022, the average electricity unit cost corresponded to an annual cost of £535/year, assuming Ofgem's typical annual consumption of 2700 kWh/year, slightly lower than the average of £562.3/year if all meters were on the Energy Price Cap due to meters on lower rate fixed tariffs. For heating season 2022/2023 the average increased to £907.1/year, which is lower compared to the average of £925.9/year if all meters were on the Energy Price Guarantee. The average increase between the seasons was £372.1/year (see Figure 14 below), an increase in percentage terms of 69.6%.

Gas standing charge

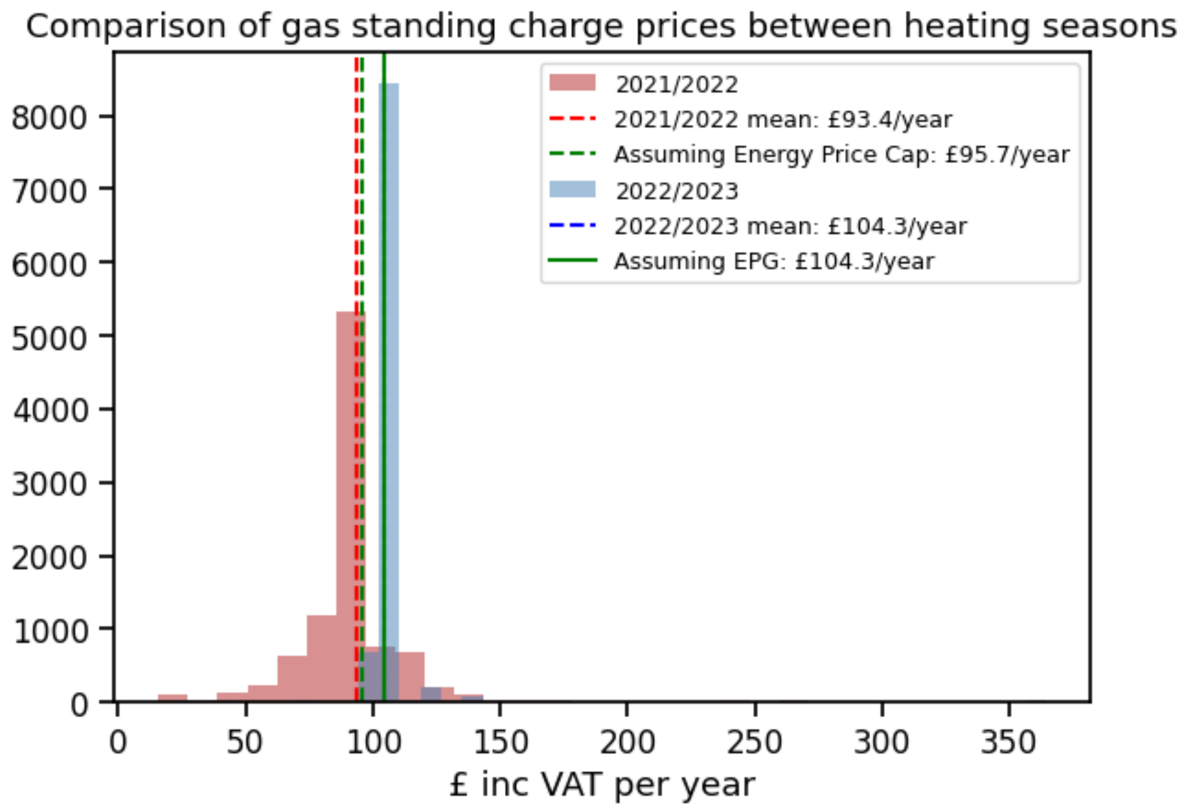

Figure 12. Histograms showing distribution of average gas standing charges on meters for heating season 2021/2022 and heating season 2022/2023.For underlying data see: hist_compare_two_seasons_gas_standing charge.csv

For heating season 2021/2022 the average gas standing charge was equivalent to a cost of £93.4/year, slightly lower than the average of £95.7/year if all meters were on the Energy Price Cap due to meters on lower rate fixed tariffs. For heating season 2022/2023 the average increased to £104.3/year. This was identical to the average if all meters were on the Energy Price Guarantee. The average increase between the seasons was £10.9/year (see Figure 14 below), an increase of 11.7%.

Gas unit cost

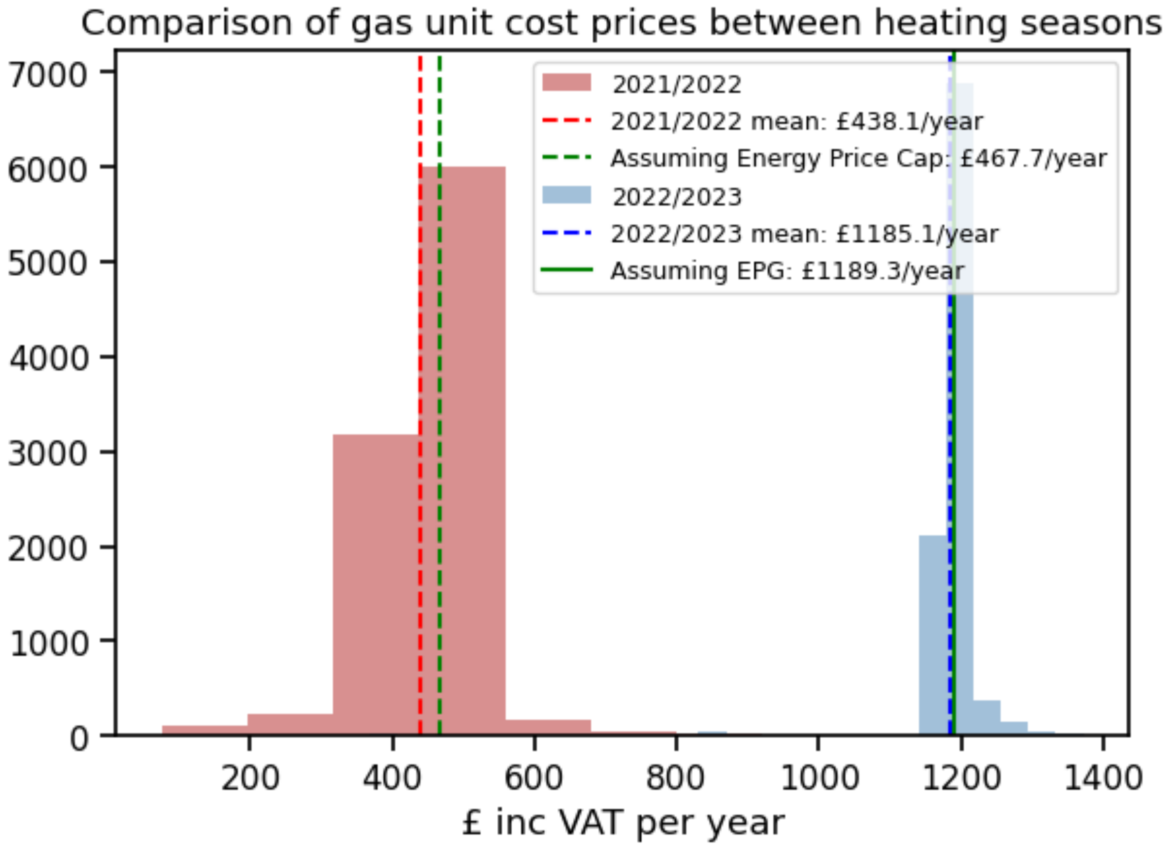

Figure 13. Histograms showing distribution of average gas unit costs on meters for heating season 2021/2022 and heating season 2022/2023. For underlying data see: hist_compare_two_seasons_gas_unit cost.csv

For heating season 2021/2022, the average gas unit cost corresponded to an annual cost of £438.1/year, assuming Ofgem's typical annual consumption of 11500 kWh/year, slightly lower than the average of £467.7/year if all meters were on the Energy Price Cap due to meters on lower rate fixed tariffs. For heating season 2022/2023 the average increased to £1185.1/year, fractionally lower than the average of £1189.3/year if all meters were on the Energy Price Guarantee. The average increase between the seasons was £747.1/year (see Figure 14 below), an increase in percentage terms of 171%.

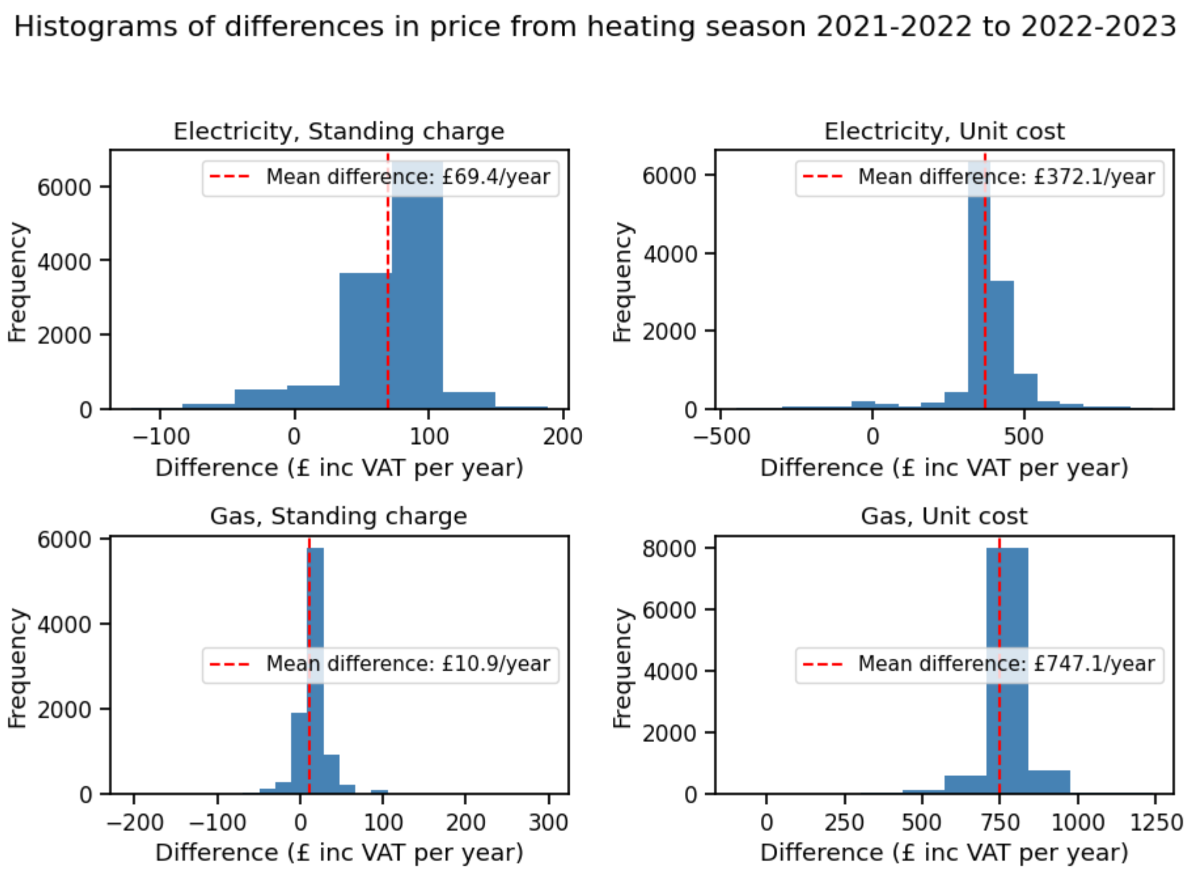

Figure 14. Histograms of the difference in energy prices on meters between heating season 2022/2023 and heating season 2021/2022. For underlying data see: hist_diff_two_seasons.csv

Fuel expenditure

The analysis above estimated expenditure associated with the different tariff components using Ofgem typical annual consumption levels. In this section actual fuel expenditure is analysed using the tariff data described above and combining it at the meter-level with energy usage. Note that the Energy Bill Support Scheme, which gave every household a £400 discount on their energy bills for the heating season 2022/2023, has not been included in any of the following analysis. All results for heating season 2022/2023 should therefore be considered as expenditure in the absence of this amount.

Energy expenditure in heating seasons 2021/2022 and 2022/2023

The following shows the distribution of actual fuel expenditure using metered energy use and energy tariff data. The following are based on counts which have been rounded to the nearest 10 to avoid statistical disclosure.

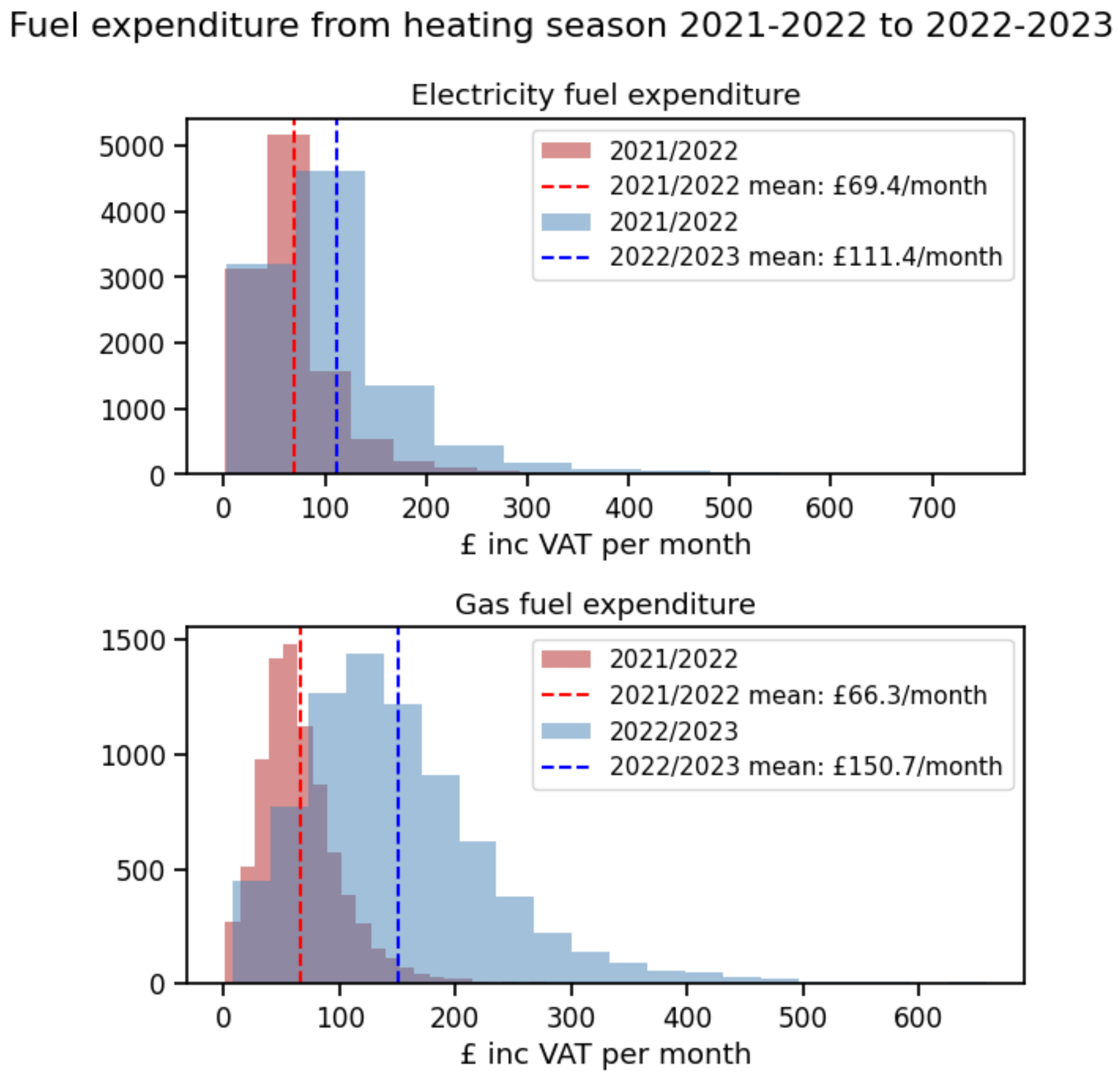

Figure 15. Histograms of actual meter-level average monthly electricity and gas expenditure for heating season 2021/2022 and heating season 2022/2023. For underlying data see: compare_fuel_expenditure_heating_seasons.csv

The results show that average (mean) electricity expenditure was £69.4/month in heating season 2021/2022, rising to £111.4/month the following heating season, an increase of 60.5%. Average gas expenditure in heating season 2021/2022 was slightly lower than electricity expenditure at £66.3/month, but gas expenditure the following heating season was considerably higher than electricity expenditure at £150.7/month, an increase of 127%, more than double the increase in electricity expenditure.

The actual fuel expenditures show skewed distributions that are characteristic of distributions of energy consumption. This is different from the distributions of estimated fuel expenditure shown in previous sections that were based on Ofgem 'typical' annual consumption levels, which are more characteristic of normal distributions.

What would energy bills have been without the Energy Price Guarantee or without people's energy saving actions?

The following shows distributions of actual energy expenditure with two counterfactual energy expenditure scenarios.

The first counterfactual scenario is: 'what if households had not made any changes to their energy use?' This is based on counterfactual modelled energy use based on the household's energy use in heating seasons 2021/2022 corrected for temperatures in 2022/2023, and combined with actual energy tariff in heating seasons 2022/2023. The counterfactual modelling method and results are described in a separate report[4].

The second scenario is: 'what if the Energy Price Guarantee had not been introduced to reduce households' energy tariff unit costs?' This counterfactual is based on meter-level actual energy use in heating season 2022/2023 combined with a counterfactual energy tariff which is the Energy Price Cap in heating season 2022/2023 based on their region and (imputed) payment status. The difference between the Energy Price Cap and the Energy Price Guarantee is the amount the Government will compensate suppliers[5].

The following are based on counts which have been rounded to the nearest 10 to avoid statistical disclosure.

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[4] McKenna, E., Few, J., Pullinger, M., Hanmer, C., Zapata-Webborn, E., Elam, S. and Oreszczyn, T., 2023. Smart Energy Research Lab: Energy use in GB gas heated domestic buildings during the 2022/2023 heating season. London: Smart Energy Research Lab, University College London. (SERL Statistical Reports, Vol. 2).
[5] Bolton, P., Stewart, I. (2023). Domestic Energy Prices (Report No. CBP-9491). UK Parliament's Commons Library. https://commonslibrary.parliament.uk/research-briefings/cbp-9491/

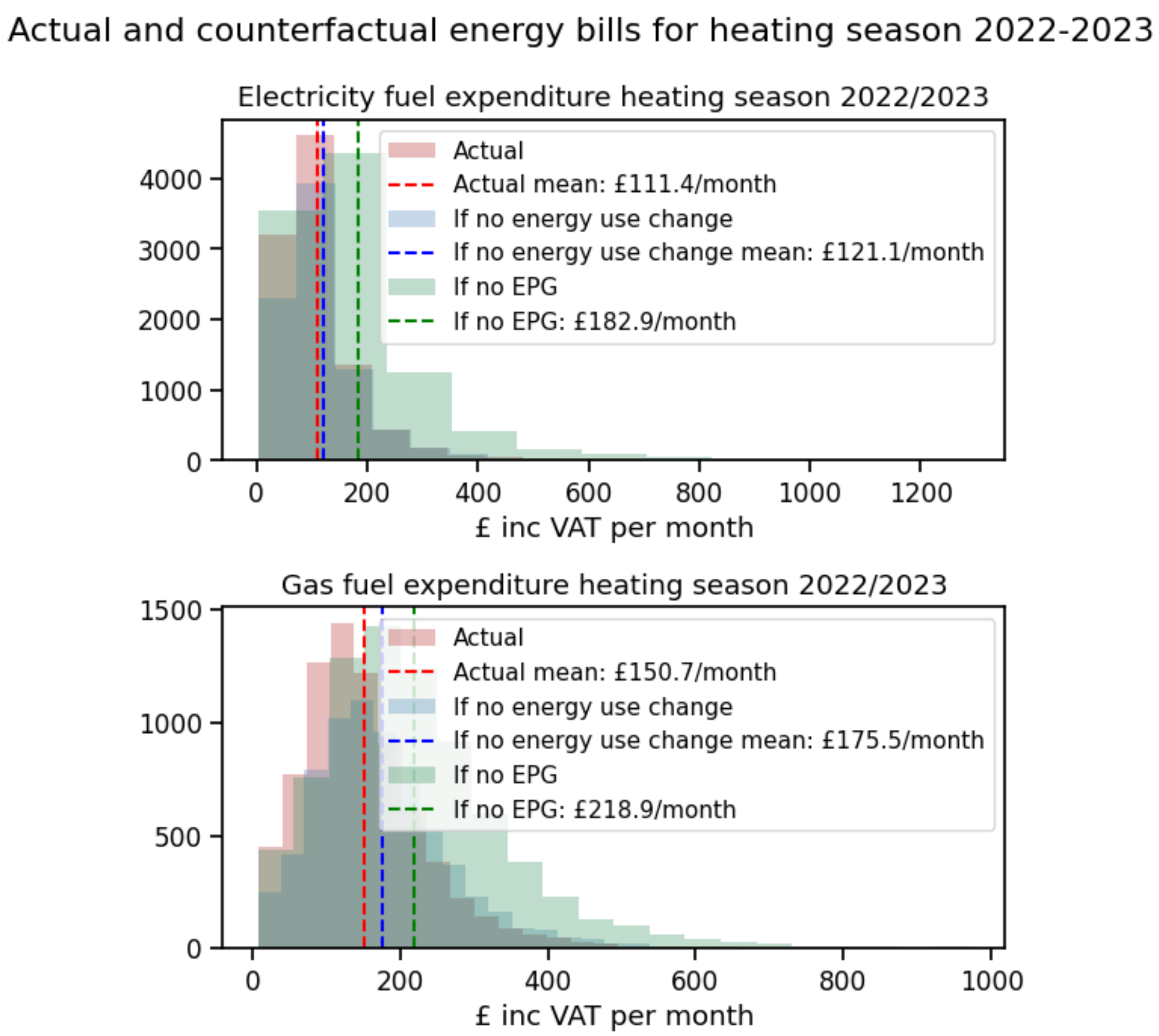

Figure 16. Histograms with corresponding means showing actual average meter-level monthly electricity and gas expenditure for heating season 2022/2023 as well as two counterfactual distributions, one assuming no energy use change, and the other assuming the Energy Price Guarantee was not in effect and prices were dictated by the Energy Price Cap instead. For underlying data see: counterfactual_fuel_expenditure_heating_seasons.csv.

The results show that the meter-level average (mean) monthly electricity expenditure for heating season 2022/2023 was £111.4/month. Compared to the previous heating seasons however, SERL Observatory participants with gas central heating reduced electricity usage by 9.09% and gas usage by 14.9% by on a temperature adjusted basis[6]. If they had not changed their energy use therefore, the average (mean) counterfactual electricity expenditure would have been £121.1/month.

If the Energy Price Guarantee had not been in effect, then the average electricity expenditure would have been £182.9/month (assuming actual electricity usage). The

[6] McKenna, E., Few, J., Pullinger, M., Hanmer, C., Zapata-Webborn, E., Elam, S. and Oreszczyn, T., 2023. Smart Energy Research Lab: Energy use in GB gas heated domestic buildings during the 2022/2023 heating season. London: Smart Energy Research Lab, University College London. (SERL Statistical Reports, Vol. 2).

average monthly gas expenditure for the same period was £150.7/month. Without energy use changes, the average gas expenditure would have been £175.5. Without the Energy Price Guarantee the average gas expenditure would have been £218.9/month.

The following figure display the same results but using box plots instead. All box plots are based on statistics that are means of the nearest 10 values to the relevant quantile. Therefore all statistics shown in the boxplots are based on 10 observations, and are a close approximation of the actual quantiles which are normally used in boxplots. Whiskers of boxplots represent thresholds calculating using the interquartile (IQR) range method[7] for identifying outliers which have been removed from the calculation of the statistics, and may therefore extend past zero even though the distribution does not.

[7] The IQR range method consists of calculating the IQR range (75% percentile minus 25% percentile), multiplying this by a factor, typically 1.5, then determining an upper bound (75% + IQR x 1.5) and lower bound (25% - IQR x 1.5). Data points outside these bounds are then considered outliers.

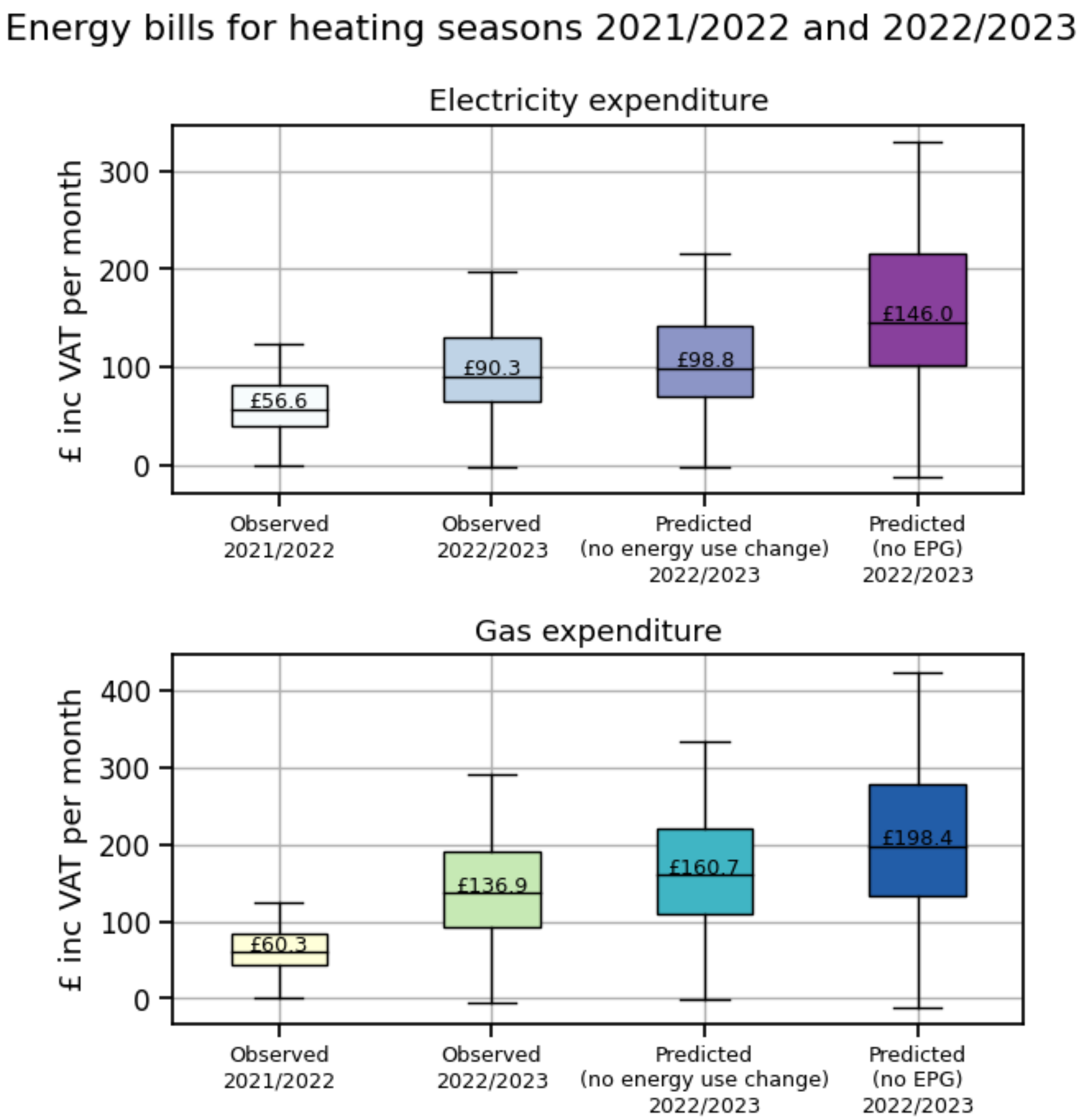

Figure 17. Box plots showing distributions of average meter-level monthly electricity and gas expenditure for heating season 2021/2022 and heating seasons 2022/2023 as well as counterfactual distributions of predicted electricity and gas expenditure in heating season 2022/2023 assuming the same energy use as 2021/2022 adjusted for 2022/2023 weather ("no energy use change"), and predicted electricity and gas expenditure assuming the same energy use in 2022/2023 but if prices were set by the Energy Price Cap rather than the Energy Price Guarantee ("no EPG"). For underlying data see: sdc_box_plots_counterfactual_fuel_expenditure_heating_seasons.csv

The results show that the average (median) meter-level monthly electricity expenditure for heating season 2021/2022 was £56.6/month, increasing to £90.3/month in heating season 2022/2023. The average (median) increase was £32.4/month. If not for changes to electricity use made by households in heating season 2022/2023, the median electricity expenditure would have been £98.8. The median effect of energy use changes on household electricity expenditure was a reduction £6.4/month. If not for the Energy Price Guarantee, the median electricity expenditure would have been £146.0/month. The median effect of the Energy Price Guarantee on household electricity expenditure was a reduction of £53.9/month.

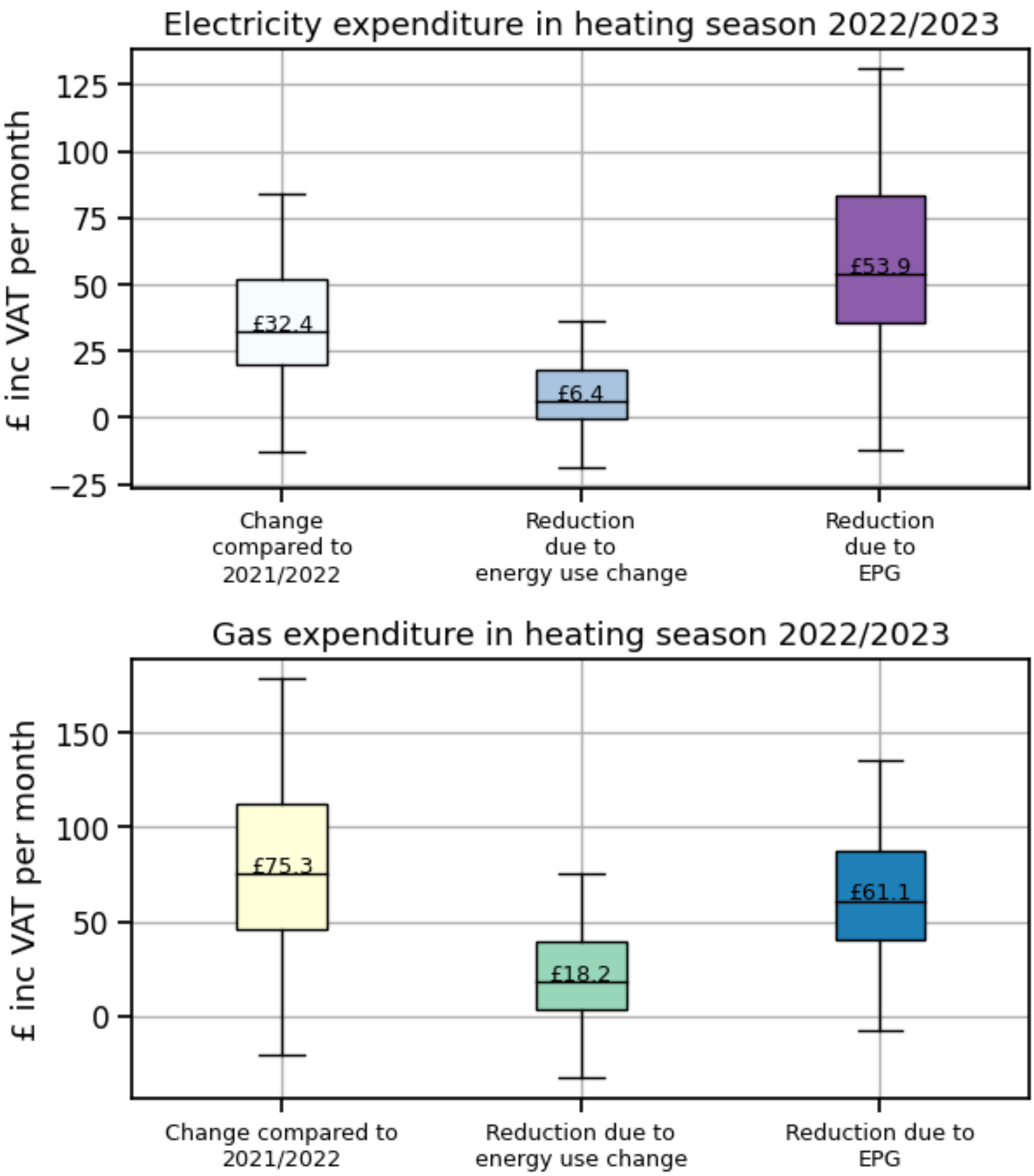

Figure 18. Box plots showing distributions of meter-level change in average monthly electricity and gas expenditure between heating season 2022/2023 and heating season 2021/2022 (left), counterfactual predicted electricity and gas expenditure in heating season 2022/2023 assuming the same energy use as 2021/2022 adjusted for 2022/2023 weather (middle), and predicted electricity and gas expenditure assuming the same energy use in 2022/2023 but if prices were set by the Energy Price Cap rather than the Energy Price Guarantee (right). For underlying data see: sdc_box_plots_changes_over_heating_seasons.csv

For gas expenditure, the average (median) meter-level monthly expenditure for heating season 2021/2022 was £60.3/month, increasing to £136.9/month in heating season 2022/2023. The average (median) increase was £75.3/month. If not for changes to gas use made by households in heating season 2022/2023, the median gas expenditure would have been £160.7/month. The median effect of gas use changes on household gas expenditure was a reduction £18.2/month. If not for the Energy Price Guarantee, the median gas expenditure would have been £198.4/month. The median effect of the Energy Price Guarantee on household gas expenditure was a reduction of £61.1/month.

Impact of energy price rises on energy bills by household income bands

The following shows box plot illustrations of distributions of changes in energy bills from heating season 2021/2022 to heating season 2022/2023, segmented by household gross income as self-reported in the cost-of-living crisis survey conducted in Jan-Feb 2023. This is based on actual energy use and actual energy tariffs in these two periods. As above, the box plots show statistics that are approximations of the quantiles normally used, based on means of the nearest 10 values to the relevant quantile, and whiskers represent thresholds for identifying and excluding outliers from the statistical calculations, not necessarily the extent of the true distribution of underlying data.

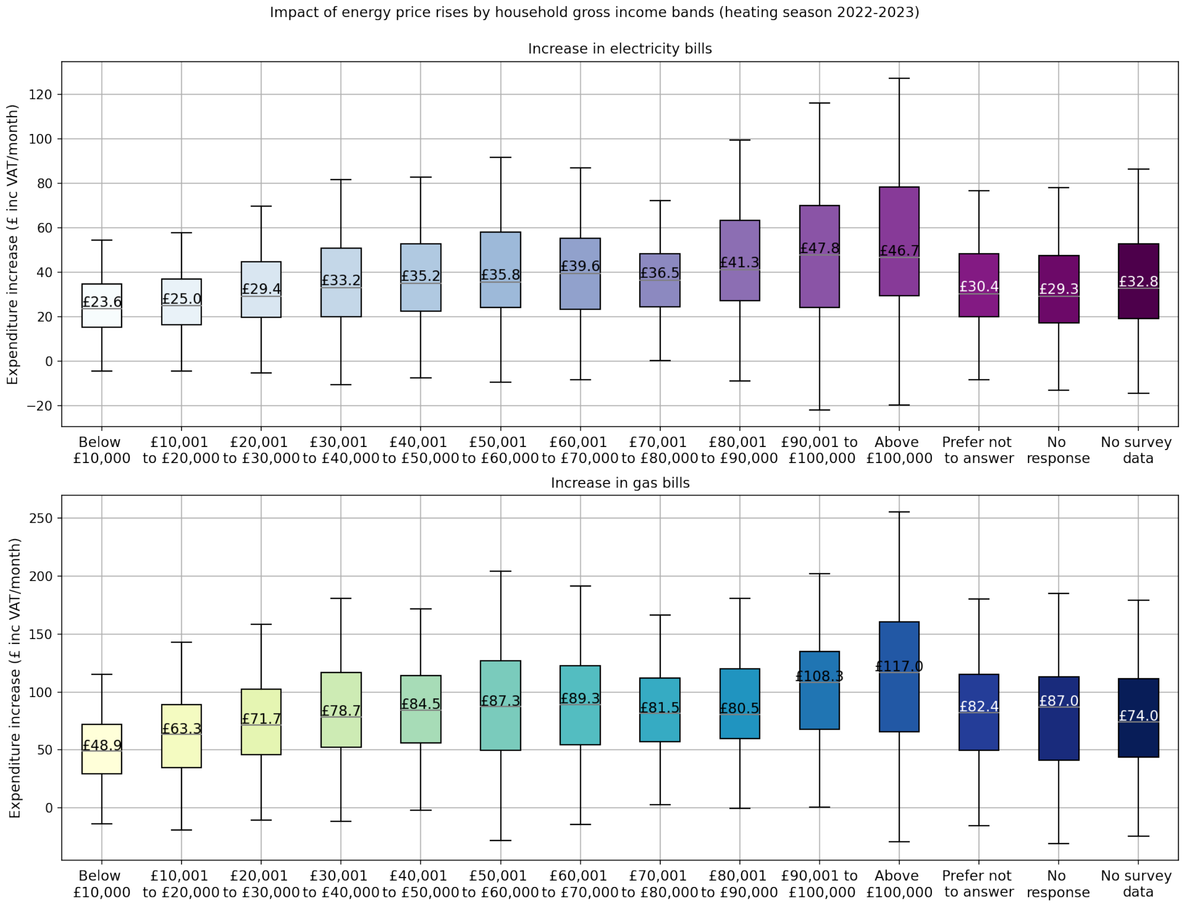

Figure 19. Box plots showing distributions of increases in electricity and gas expenditure between heating season 2021/2022 and 2022/2023 by self-reported household gross income bands. For underlying data see: sdc_box_plots_change_energy_bills_by_income_pc_False.csv

The results show how the increases in electricity and gas expenditure in heating season 2022/2023 were distributed across households gross income bands. In general, higher income households experienced larger increases in both electricity and gas expenditure. The median increase in household electricity expenditure for households in the lowest gross income bands was £23.6/month for households with gross income below £10,000 and £25.0/month for households in the £10,001 to £20,000 band. The increase was around double that for households in the top two gross income bands: £47.8/month and 46.7/month.

The results are similar for gas expenditure. The households in the lowest two income bands had increases in gas expenditures of £48.9/month and £63.3/month, compared to £108.3/month and £117.0/month for households in the top two income bands.

This variation in the increase in energy bills by household income could be driven by two factors: correlation between income and increases in energy prices, and correlation between income and energy use. We have not investigated the former in this analysis, though we note that as price rises have been primarily driven by external factors and there were low volumes of switching during this period, this correlation is unlikely.

By contrast, the latter correlation is well-established. Higher income households are more likely to live in larger dwellings, and use more gas and electricity than lower income households, and so this is likely to explain the correlation between income and increases in energy bills observed here.

We also note that this analysis does not include the impact of the £400 Energy Bills Support Scheme. This was applied on a monthly basis over 6 months i.e. £66 or 67 per month. This would have significantly counteracted the increase in bills observed here. For example, households in the lowest income saw a combined increase of £72.5/month, which would have been almost completely compensated by the monthly EBSS payment.

When considered as percentage increases, the picture is more uniform, with broadly similar median increases in electricity and gas expenditure across household gross income bands. Overall, the results suggest that lower income households were likely to have been disproportionately affected by the increases in both electricity and gas expenditure.

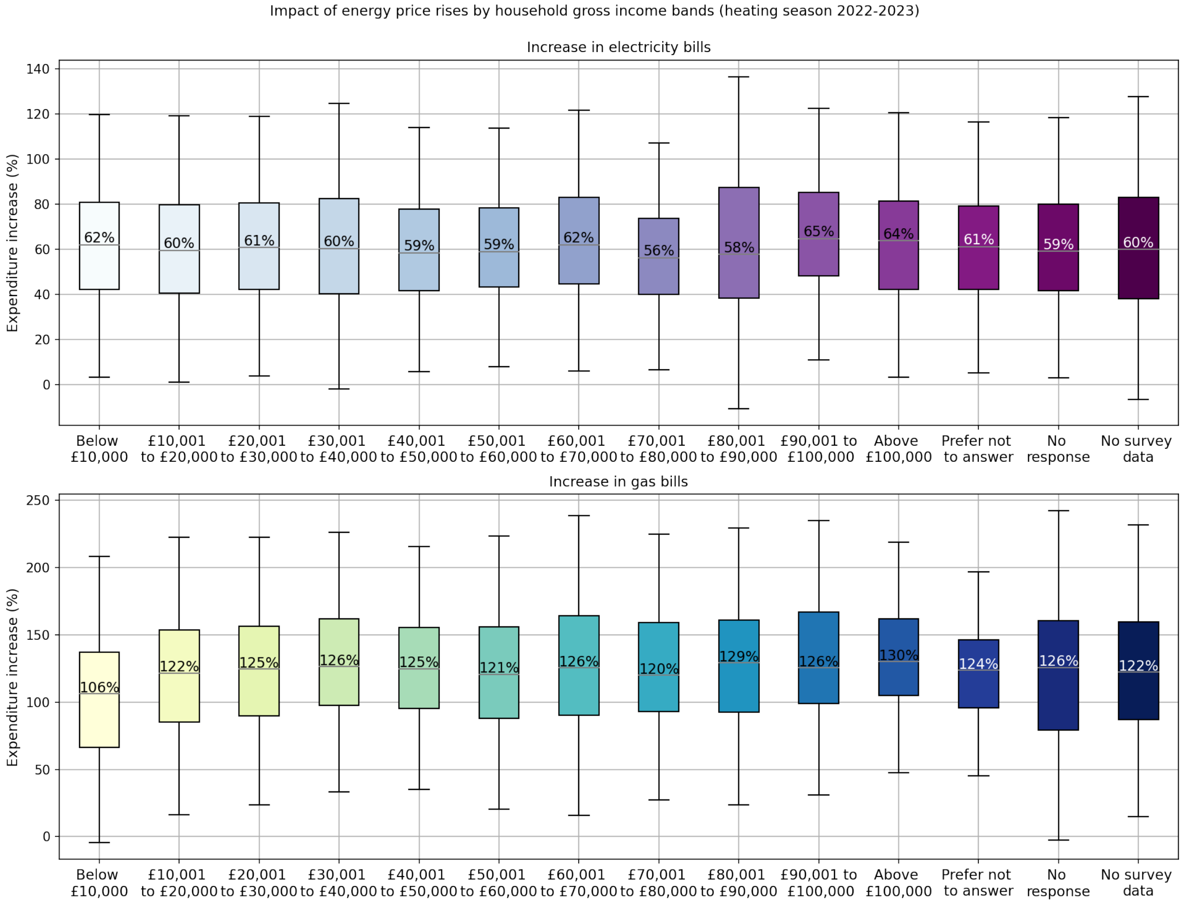

Figure 20. Same as previous figure but in terms of percentage change rather than absolute change. For underlying data see: sdc_box_plots_change_energy_bills_by_income_pc_True.csv

Impact of Energy Price Guarantee on energy bills by household income bands

The following shows distributions of the change in energy bills in heating season 2022/2023 due to the Energy Price Guarantee, segmented by household gross income. This is the different between actual energy bills in heating season 2022/2023 and the counterfactual energy bill assuming actual energy use in heating season 2022/2023 combined with the counterfactual energy tariff of the Energy Price Cap in heating season 2022/2023. As above, all box plots are based on statistics which are means of the nearest 10 values to the relevant quantiles normally used in box plots.

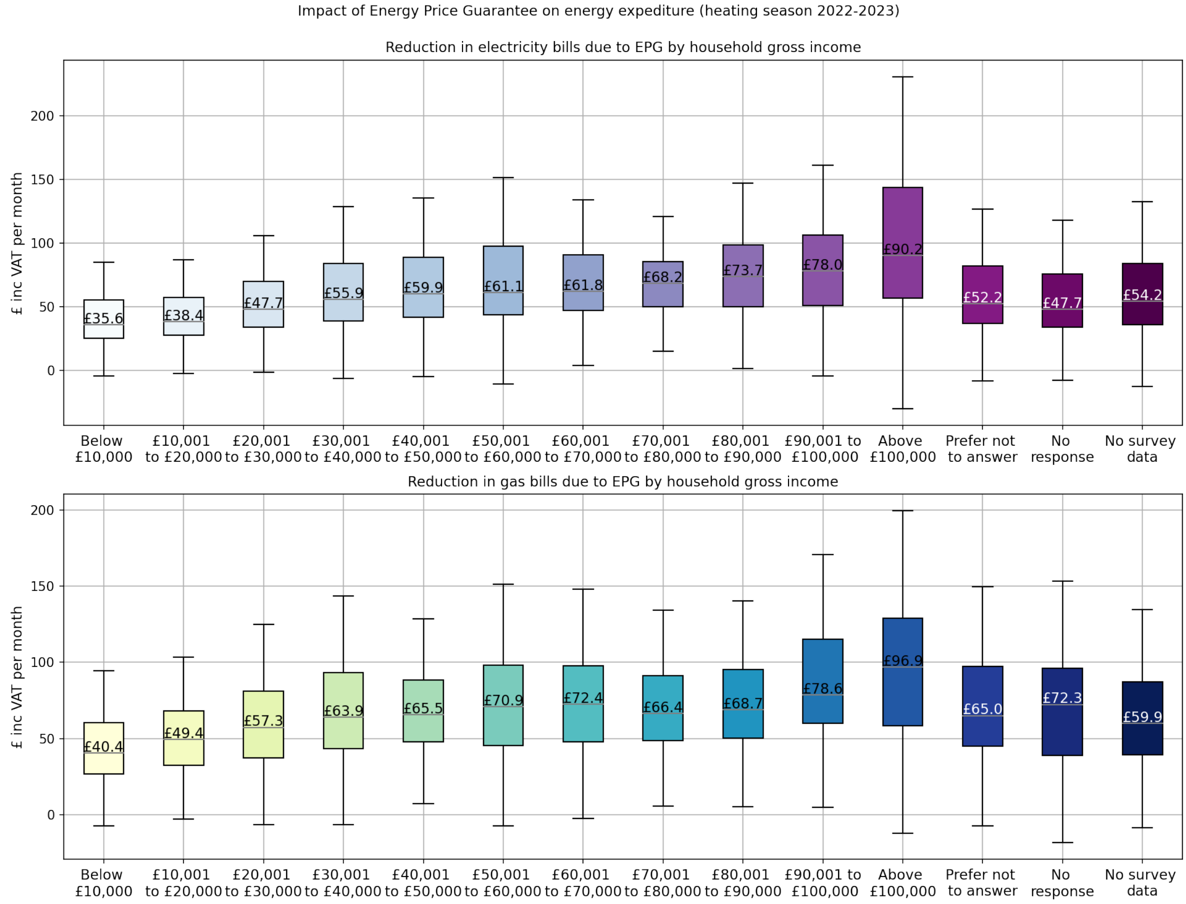

Figure 21. Box plots illustrating the distribution of reductions in monthly electricity and gas expenditure in heating season 2022/2023 due to the Energy Price Guarantee by self-reported household gross income band. For underlying data see: sdc_box_plots_epg_subsidy_by_income.csv

The results show a general trend of households with higher incomes benefitting more than households with lower incomes from the Energy Price Guarantee. For households in the lowest two income bands, the median reduction in electricity expenditure due to the EPG was £35.6/month and £38.4/month, while for households in the top two income bands the median reduction was £78.0/month and £90.2/month. For gas expenditure, the median reduction due to the EPG was £40.4/month and £49.4/month for households in the poorest two income bands, and £78.6/month and £96.9/month for households in the top two income bands.

Impact of energy use behaviour change by household income bands

As mentioned previously, households in the SERL Observatory reduced electricity and gas usage in the heating season of 2022/2023 compared to the previous heating season. On a temperature adjusted basis, the reduction in gas usage for households with gas central heating in heating season 2022/2023 was -7.96 kWh/day per household or -14.90%, and the reduction in electricity usage was -0.88 kWh/day per household, or a change in percentage terms of -9.09%[8]. The following figure shows box plots that illustrate how the change in electricity and gas usage (in percentages terms) varied by self-reported household gross income. As above, all box plots are based on statistics which are means of the nearest 10 values to the relevant quantiles normally used in box plots, and whiskers represent thresholds for identifying and excluding outliers from the statistical calculations, not necessarily the extent of the true distribution of underlying data. Note however for these distributions it is possible to have an increase in energy use occurring in heating season 2022/2023 compared to heating season 2021/2022, and therefore an increase or 'negative reduction' in energy expenditure.

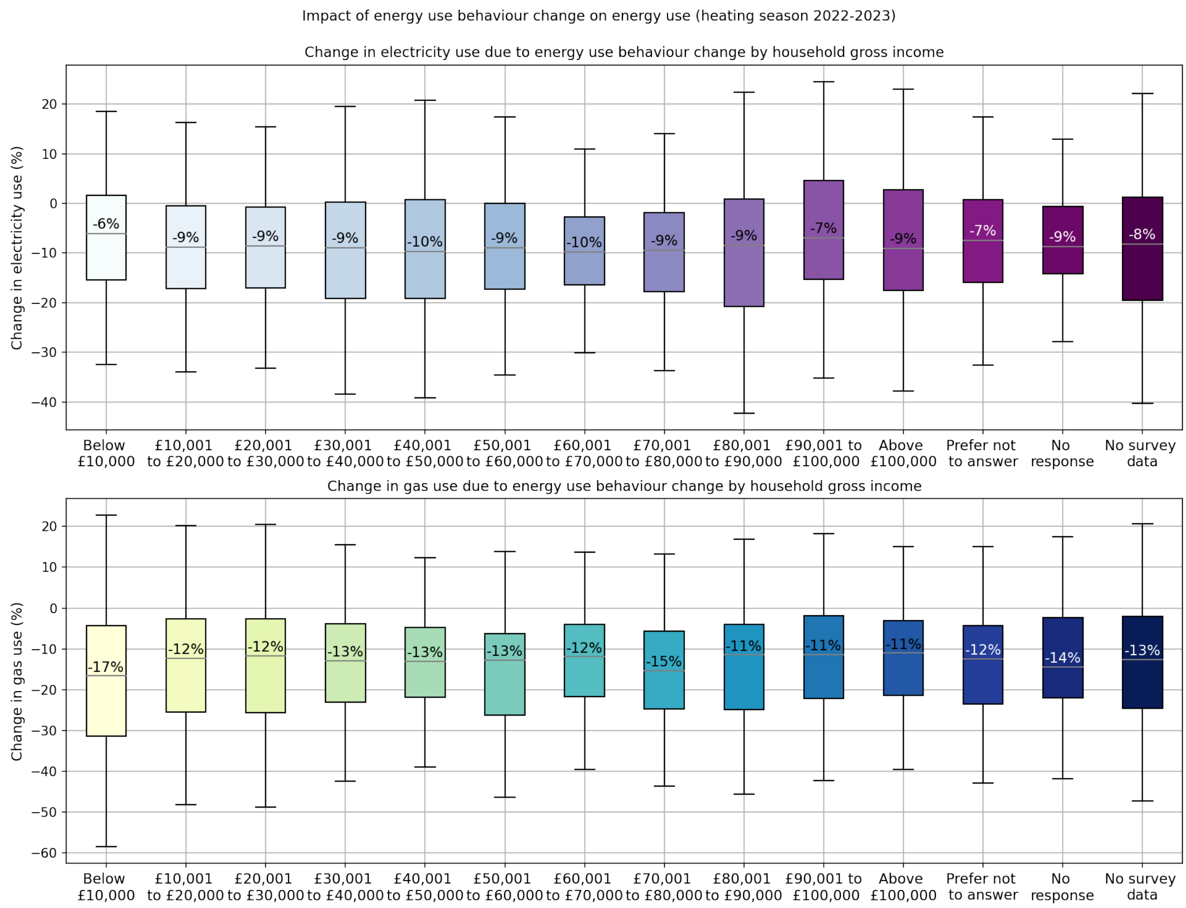

Figure 22. Box plots illustrating the distributions of changes in electricity and gas use in heating seasons 2022/2023 compared to predicted counterfactual energy use for the same period i.e. due to household energy

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[8] McKenna, E., Few, J., Pullinger, M., Hanmer, C., Zapata-Webborn, E., Elam, S. and Oreszczyn, T., 2023. Smart Energy Research Lab: Energy use in GB gas heated domestic buildings during the 2022/2023 heating season. London: Smart Energy Research Lab, University College London. (SERL Statistical Reports, Vol. 2).

use changes by household gross income. For underlying data see: sdc_box_plots_change_due_to_energy_use_change_by_income_pc_True.csv*

The results show fairly consistent median changes in electricity and gas usage by household gross income; a reduction of around 9-10% for electricity usage and 11-13% for gas usage. Households in the bottom income band show higher median reduction in gas usage of 17% though the distribution is also larger indicating greater uncertainty around this estimate. They were also associated with smaller reductions in electricity usage at 6%.

The following shows distributions of the change in energy bills in heating season 2022/2023 due to these changes in energy use. This is the different between actual energy bills in heating season 2022/2023 and the counterfactual energy bill assuming counterfactual energy use in heating season 2022/2023 combined with actual (imputed) energy tariff in heating season 2022/2023.

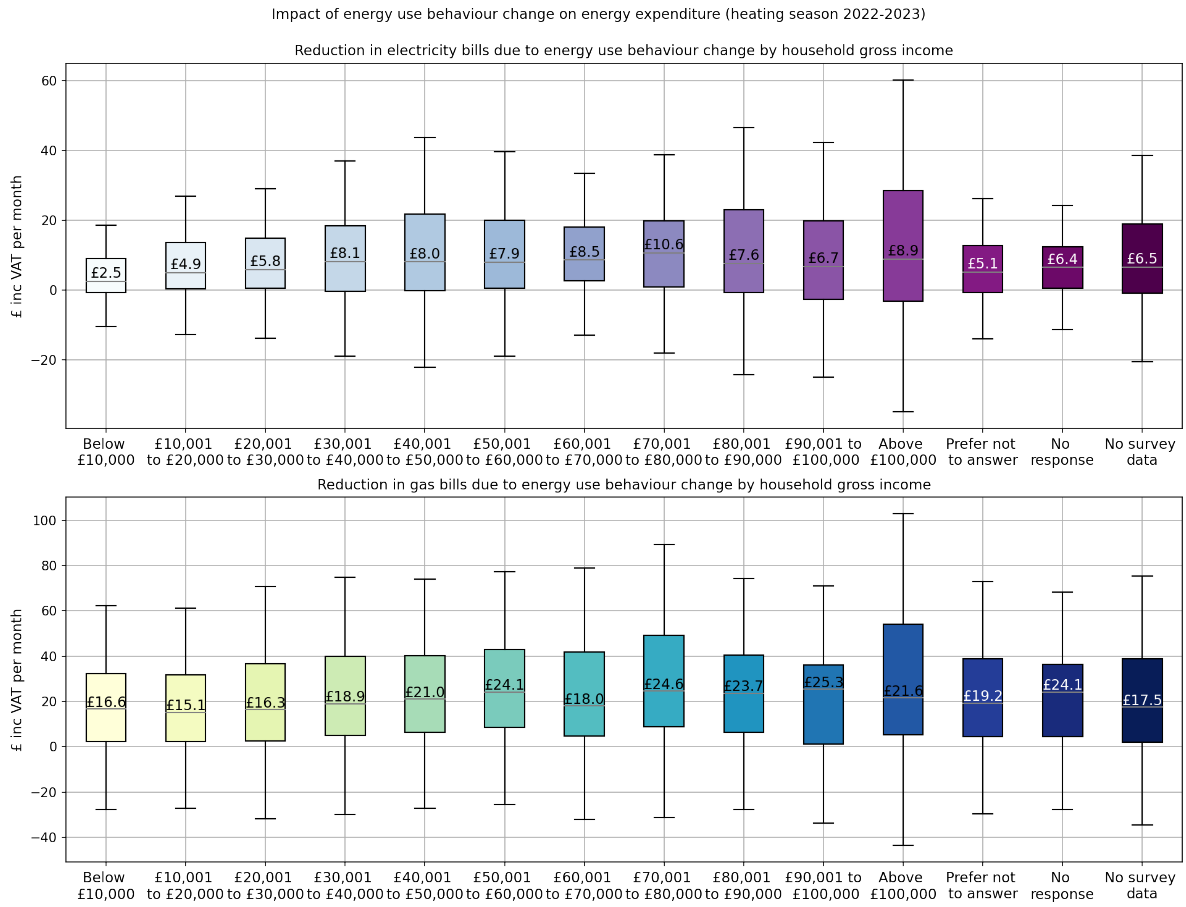

Figure 23. Box plots illustrating the distributions of reductions in electricity and gas expenditure in heating seasons 2022/2023 due to household energy use changes by household gross income. For underlying data see: sdc_box_plots_change_due_to_energy_use_change_by_income_pc_False.csv

The results show a general trend of households with higher incomes achieving larger reductions in gas and electricity expenditure due to changes in energy use occurring in heating season 2022/2023 than households with lower incomes. For electricity expenditure, the median reduction for households in the lowest income bands was £2.5/month and £4.9/month, compared to £6.7/month and £8.9/month for households in the top two income bands. For gas expenditure, the difference between top and bottom is smaller. Households in the bottom two income bands had median reductions in gas expenditure of £16.6/month and £15.1/month versus £25.3/month and £21.6/month for the top two income bands.

Price elasticity of electricity and gas use

The following shows distributions of price elasticity of electricity and gas use. This is calculated as the household-level percentage change in energy use between heating season 2021/2022 and heating season 2022/2023 divided by the household-level percentage change in energy unit cost between the same periods. A single point estimate of price elasticity is therefore calculated for each household, and the following histograms and box plots illustrate the distributions of these point estimates.

Temperature adjusted price elasticities are also illustrated. These are calculated as the household-level percentage difference in energy use between the counterfactual modelled energy use for heating season 2022/2023 and actual metered energy use in heating season 2022/2023 divided by the household-level percentage change in energy unit cost between heating season 2021/2022 and heating season 2022/2023.

Outliers have been filtered out using the interquartile range (IQR) method and are not displayed nor included in the calculation of statistics.

In the following histograms the counts have been rounded to the nearest 10 to avoid statistical disclosure, and outliers have been removed using the IQR method.

A summary table of statistics for the distributions of the various price elasticities is included below. The median is the mean of the nearest 10 values to the real median.

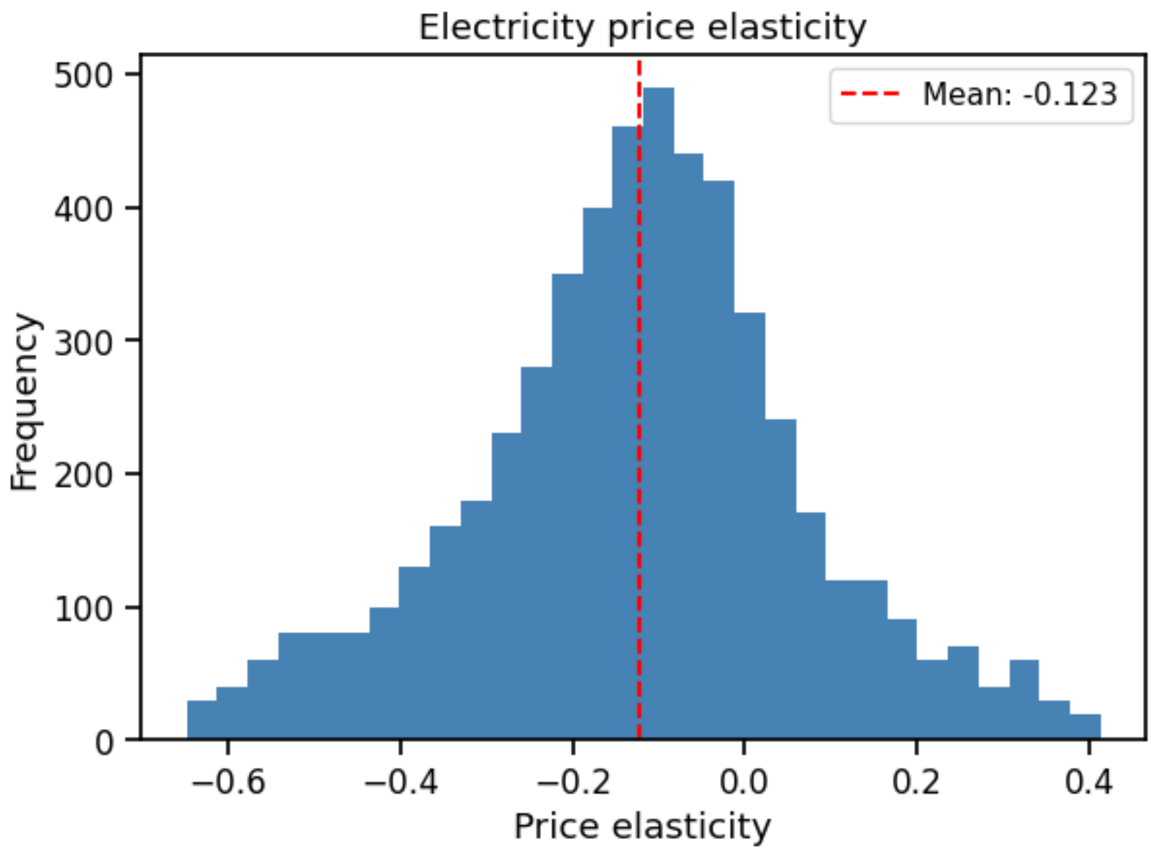

Figure 24. Histogram of meter-level point estimates of price elasticity of electricity usage between heating season 2021/2022 and heating season 2022/2023. For underlying data see: sdc_hist_price_elasticity_electricity_temp_adj_False.csv

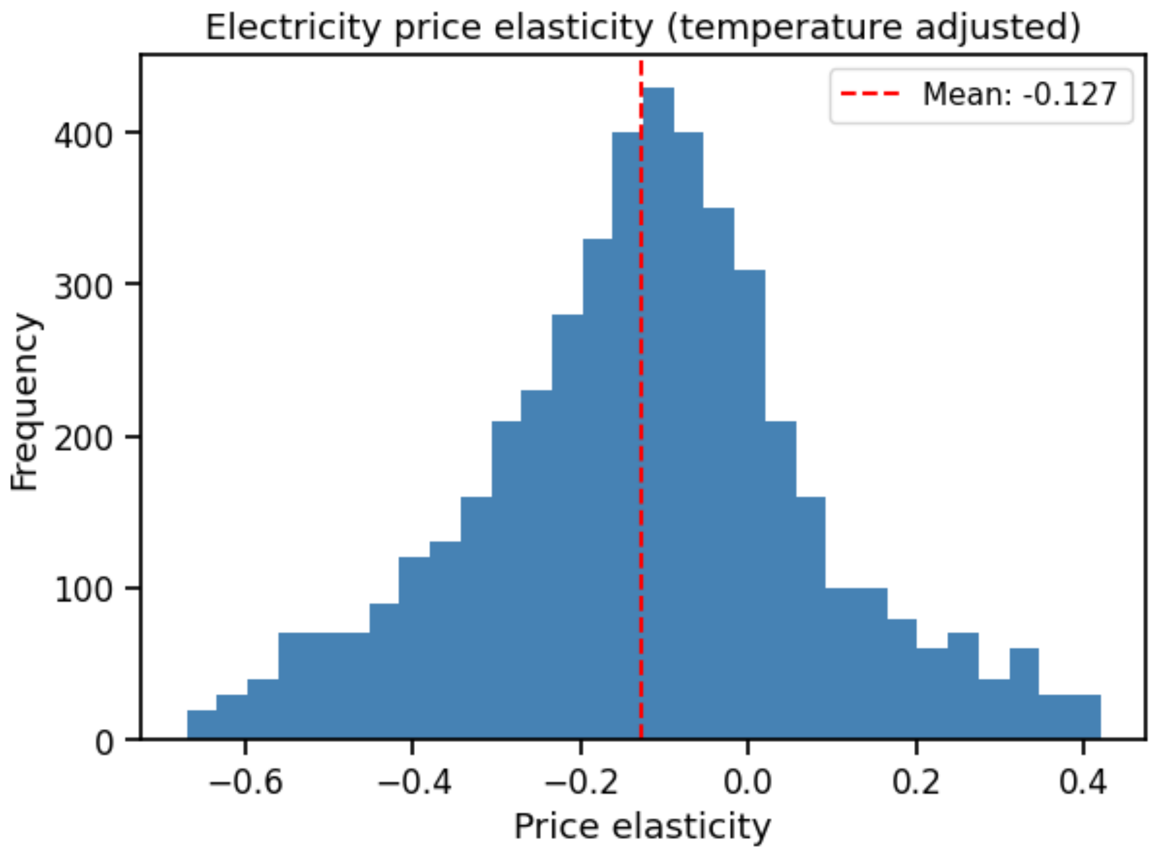

Figure 25. Histogram of meter-level point estimates of price elasticity of temperature-adjusted electricity usage between heating season 2021/2022 and heating season 2022/2023. For underlying data see: sdc_hist_price_elasticity_electricity_temp_adj_True.csv

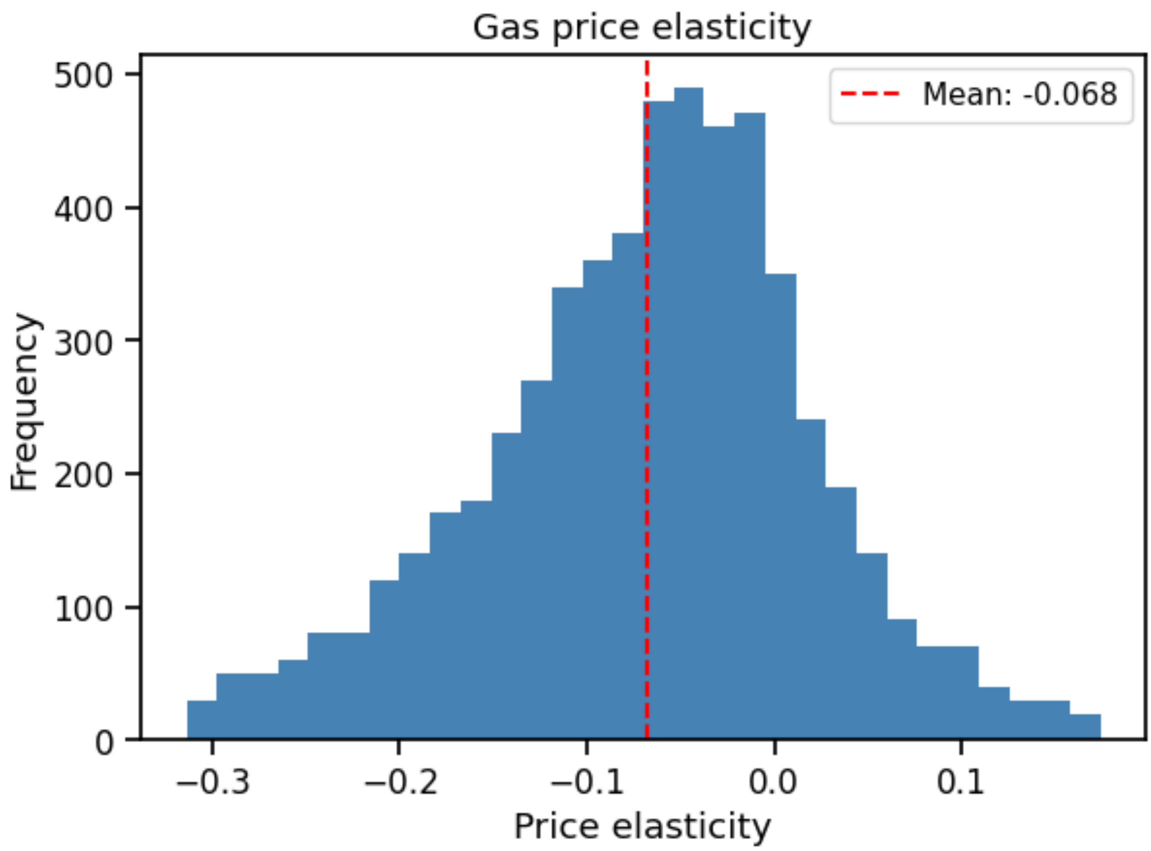

Figure 26. Histogram of meter-level point estimates of price elasticity of gas usage between heating season 2021/2022 and heating season 2022/2023. For underlying data see: sdc_hist_price_elasticity_gas_temp_adj_False.csv

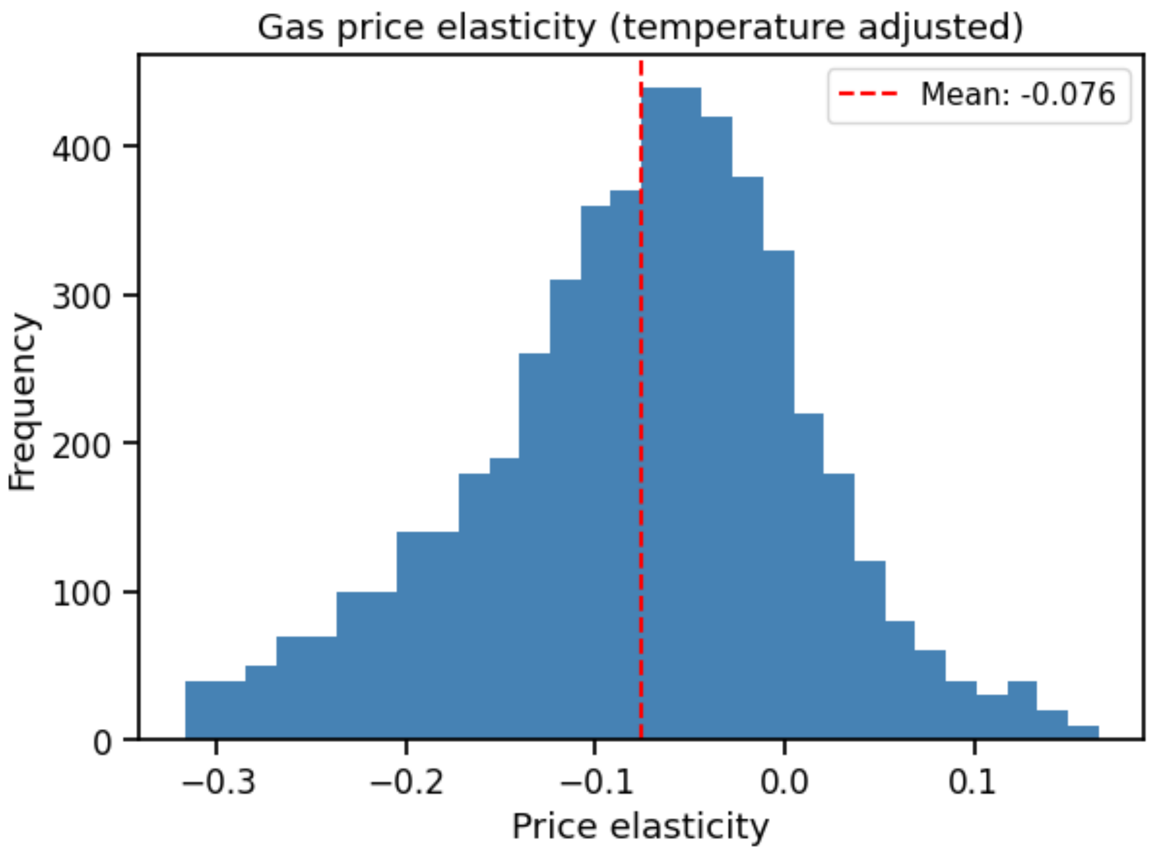

Figure 27. Histogram of meter-level point estimates of price elasticity of temperature-adjusted gas usage between heating season 2021/2022 and heating season 2022/2023. For underlying data see: sdc_hist_price_elasticity_gas_temp_adj_True.csv

The results show the distributions of the meter-level point elasticity estimates, which show a reasonable approximation to normal distributions with considerable spread. The mean of the distributions are all negative, indicating that an increase in price is associated with a reduction in usage. The mean price elasticity of electricity is -0.123 with a 95% confidence interval of (-0.128 to -0.118), meaning a 100% increase in electricity unit cost is associated with a 12.3% reduction in electricity usage. The temperature adjusted price elasticity of electricity demand takes into account the reduction in electricity use accounting for the difference in temperature between heating season 2021/2022 and heating season 2022/2023 and the mean of this distribution is -0.127 (95% confidence interval: -0.133 to -0.121).

For gas, the price elasticity is -0.068 (95% confidence interval: -0.070 to -0.066), and the temperature adjusted price elasticity is -0.076 (95% confidence interval: -0.079 to -0.074), indicating that a 100% increase in price is associated with a 6.8% reduction in gas usage or 7.6% reduction on a temperature adjusted basis. A review of gas price elasticities published by DECC in 2016[9] reported estimated short-run gas price elasticities for UK between -0.1 and -0.28 and which suggested that real price elasticity lies towards the lower end of the range. The estimates here are lower than -0.1, however the gas price rises experience in 2022 were unprecedented in scale and speed compared to historic gas prices that would have been used for the other estimates, and this could explain the lower observed price elasticities.

Table 5. Summary statistics of price elasticity estimates.

Energy use	**Temperature adjusted**	**Price elasticity (mean)**	**Sample size (N)**	**Price elasticity (median)**	**Standard deviation**	**95% confidence interval for the estimate of the mean**
Electricity	No	-0.123	5391	-0.115	0.196	(-0.128 - -0.118)
Electricity	Yes	-0.127	4670	-0.119	0.2	(-0.133 - -0.121)
Gas	No	-0.068	5714	-0.06	0.088	(-0.070 - -0.066)
Gas	Yes	-0.076	5246	-0.069	0.087	(-0.079 - -0.074)

The DECC report on gas price elasticities suggested that lower income groups possessed higher price elasticities and were more sensitive to changes in price than higher income groups. The following therefore presents box plots of the price elasticities segmented by household gross income band. These are based on approximations of the quantiles usually used in box plots, they are the mean of the nearest 10 values to the appropriate quantile.

The median temperature adjusted gas price elasticity for households in the lowest income band was -0.1, compared to -0.07 for households in the top income band. However there

[9] ANNEX D Gas price elasticities: the impact of gas prices on domestic consumption – a discussion of available evidence. 2016. Department of Energy and Climate Change. https://assets.publishing.service.gov.uk/media/5a74aee040f0b61df4777a1a/Annex_D_Gas_price_elasticities.pdf

does not appear to be an obvious correlation between household income and gas price elasticity.

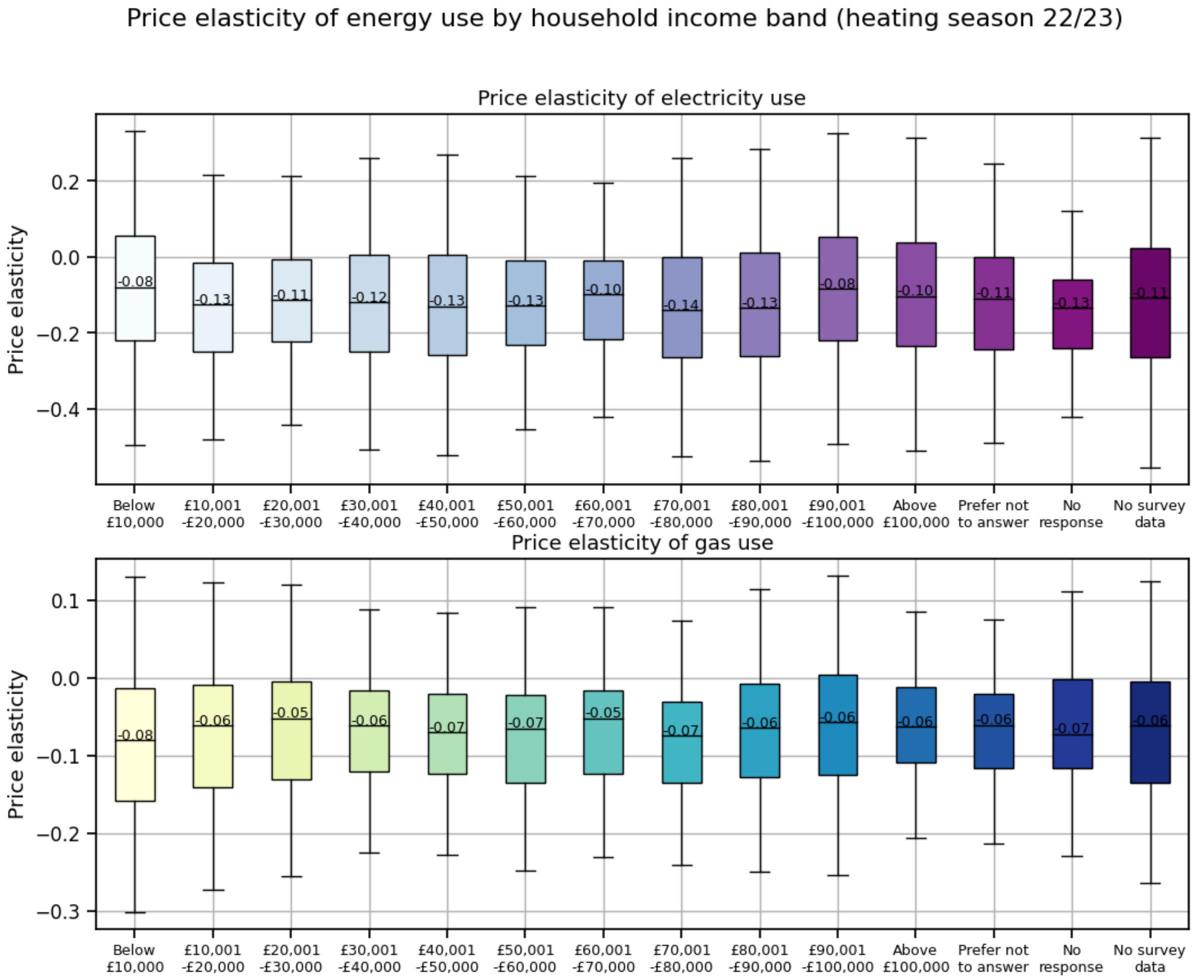

Figure 28. Box plots illustrating the distribution of meter-level point estimates of price elasticity of electricity and gas usage between heating season 2021/2022 and heating season 2022/2023. For underlying data see: sdc_box_plots_price_elasticity_by_income_temp_adh_False.csv

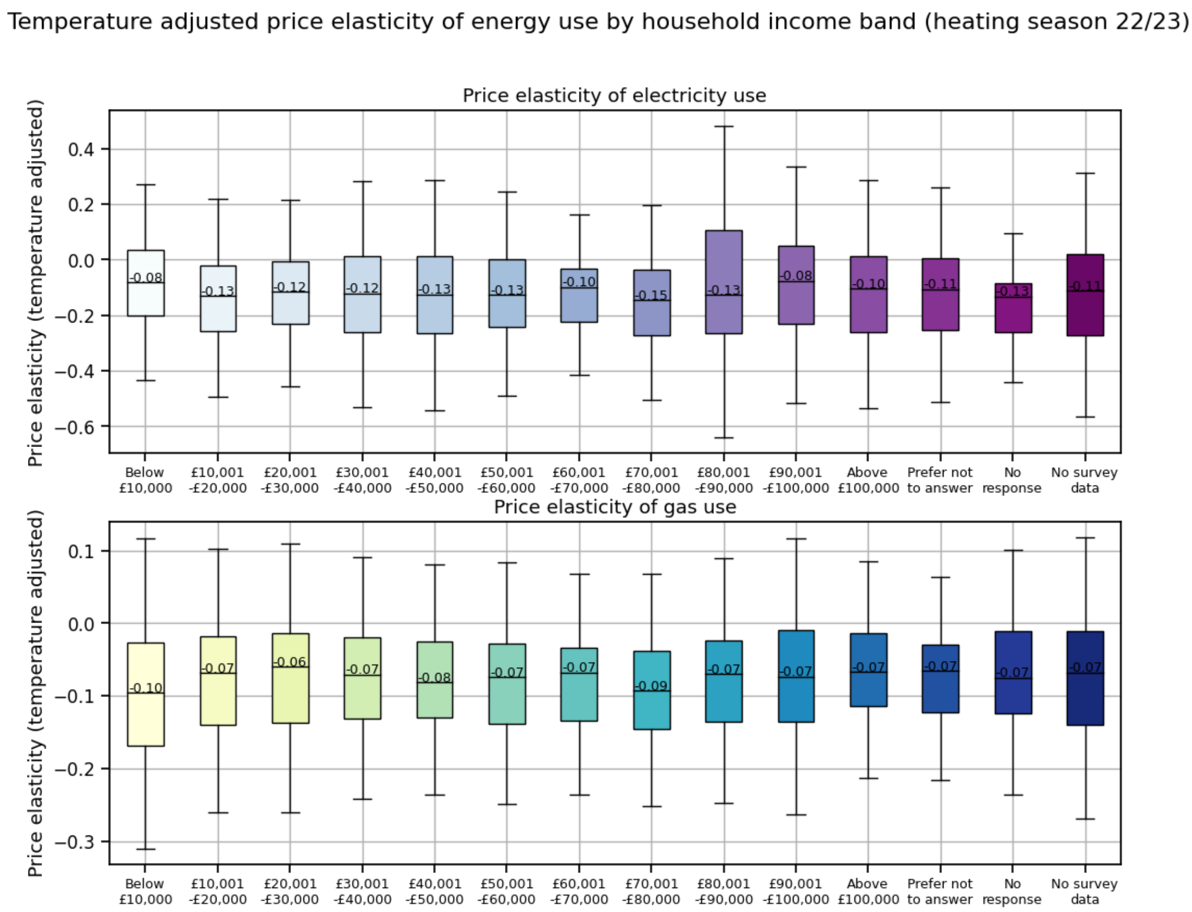

Figure 29. Box plots illustrating the distribution of meter-level point estimates of temperature-adjusted price elasticity of electricity and gas usage between heating season 2021/2022 and heating season 2022/2023. For underlying data see: sdc_box_plots_price_elasticity_by_income_temp_adh_True.csv

Price elasticity calculated using OLS regression

The above provides estimates of price elasticity that are based on means or medians of the distribution of household-level point price elasticities. The following provides an alternative method of estimating the price elasticities by using Ordinary Least Squares linear regression to estimate the statistical association between percentage change in energy unit cost between the two heating seasons and either the percentage change in energy use between the two heating seasons (the ‘not temperature adjusted’ model) or the percentage change in temperature adjusted energy use using the counterfactual modelled energy use for heating season 2022/2023 (the ‘temperature adjusted’ model).

It is common to include an intercept coefficient in regression models. The intercept captures the baseline value of the dependent variable and allows the regression line to shift up or down along the response-axis. Not including an intercept forces the regression line to pass through the origin, which can be unrealistic depending on the scenario. In the present situation however the model without an intercept is appropriate as the estimate of the price elasticity coefficient can be interpretated as the price elasticity that gives the best fit to the data which consists of point estimates of price elasticity for the individual meters in the sample. The estimate can be considered the price elasticity of the group, and can be directly compared to the price elasticity estimates calculated above as the mean or median of the distributions.

For the model with intercept, the interpretation of the coefficients is less intuitive. As the intercept allows the regression line to shift up and down, the gradient of the line might capture the association between of variation in change in price *between* households on variation in change in usage between households. It is not clear if this is a meaningful coefficient and so these results are provided for interest only.

*Table 6. Summary of results of OLS regression estimates of price elasticity for various models: with and without temperature adjusted energy usage, and with and without including an intercept in the regression model. Statistical significance level: *** >99.9%, **>99%, *>95%.*

Meter type	Model	No. observations	Price elasticity coefficient estimate (95% confidence interval)	Intercept coefficient estimate, if applicable (95% confidence interval)
Electricity	Not temperature adjusted, no intercept	5391	-0.0785*** (-0.083, -0.074)	n/a
Electricity	Temperature adjusted, no intercept	4665	-0.0873*** (-0.092, -0.083)	n/a
Electricity	Not temperature adjusted, with intercept	5391	-0.0023 (-0.01, 0.005)	-8.7062*** (-9.402, -8.011)
Electricity	Temperature adjusted, with intercept	4665	-0.0127** (-0.021, -0.004)	-8.1261*** (-8.886, -7.367)
Gas	Not temperature adjusted, no intercept	5714	-0.0467*** (-0.049, -0.045)	n/a

Gas	Temperature adjusted, no intercept	5257	-0.051*** (-0.053, -0.049)	n/a
Gas	Not temperature adjusted, with intercept	5714	-0.0079*** (-0.011, -0.005)	-10.6606*** (-11.396, -9.926)
Gas	Temperature adjusted, with intercept	5257	-0.0086*** (-0.012, -0.005)	-11.5943*** (-12.424, -10.765)

The OLS regression without intercept results in estimates of price elasticity that are comparable but lower than the previous estimates based on averages of distributions. Electricity price elasticity is estimated at -7.85% and temperature adjusted electricity price elasticity at -8.73%, compared to the previous estimates of -12.3% and -12.7%. Gas price elasticity is estimated at -4.67% and temperature adjusted gas price elasticity at -5.1%, compared to the previous estimates of -6.8% and -7.6%.

Clearly there is a discrepancy between estimates for the two approaches. However while both approaches describe aspects of the relationship between change in price and change in usage, they do so in different ways. The regression approach is based on the assumption that there is a single underlying linear relationship between change in price and change in demand which each household deviates from in a random way. It imposes an assumption of a particular structural relationship between variables, and it is not obvious that this is a valid assumption. The previous approach, however is based simply on the average of the distribution of household-level observations. It imposes no assumed structure on the relationship between the variables, and is therefore the recommended estimate to use.

Acknowledgements

The SERL Observatory dataset used in this research continues to be collected and periodically released for use by GB researchers on approved projects. The SERL Observatory dataset has been collected and made available to the UK research community by the Smart Energy Research Lab (SERL) via funding from EPSRC-funded research project EP/P032781/1. We would like to thank the 13,000+ SERL Observatory households who have consented access to their smart meter data, without whom it would not have been

possible to undertake this research. The SERL Observatory data is available to UK accredited researchers via the UK Data Service.

Data: Elam, S., Webborn, E., Few, J., McKenna, E., Pullinger, M., Oreszczyn, T., Anderson, B., Ministry of Housing, Communities and Local Government, European Centre for Medium-Range Weather Forecasts, Royal Mail Group Limited. (2023). *Smart Energy Research Lab Observatory Data, 2019-2022: Secure Access.* [data collection]. *5th Edition.* UK Data Service. SN: 8666, DOI: http://doi.org/10.5255/UKDA-SN-8666-6

Data descriptor: Webborn E, Few J, McKenna E, Elam S, Pullinger M, Anderson B, et al. *The SERL Observatory Dataset: Longitudinal Smart Meter Electricity and Gas Data, Survey, EPC and Climate Data for Over 13,000 GB Households*. Energies (Basel) 2021;14. https://doi.org/10.3390/en14216934.

The SERL Observatory includes European Centre for Medium-Range Weather Forecasts (ECMWF) ERA5 data. Neither the European Commission nor the ECMWF is responsible for any use that may be made of the Copernicus information or data it contains.

The production of this report was funded by the Department of Energy Security and Net Zero. This project has been approved by UCL Research Ethics, and access to SERL Observatory data for the purposes of this project has been approved by the SERL Data Governance Board. All researchers accessing SERL Observatory data are Accredited Researchers.

Appendix – tariff data quality assurance and methods

Tariff data

The purpose of this section is to describe the tariff data, the data processing done to it, to consider the quality of the data, and to analyse the data.

It is important to note that this tariff data is *not* the tariff data that energy suppliers use for billing. Energy suppliers have tariff data for each of their customers which they use for billing, and the tariff data that is stored on meters depends on suppliers taking the tariff data that they have and updating the tariff data on the meter. This means any issues observed with tariff data reported here should not be taken as evidence that there are any issues with billing.

Data availability / missing data

We will first consider how much missing data is an issue. The following shows how the number of meters where we have tariff data varies over time.

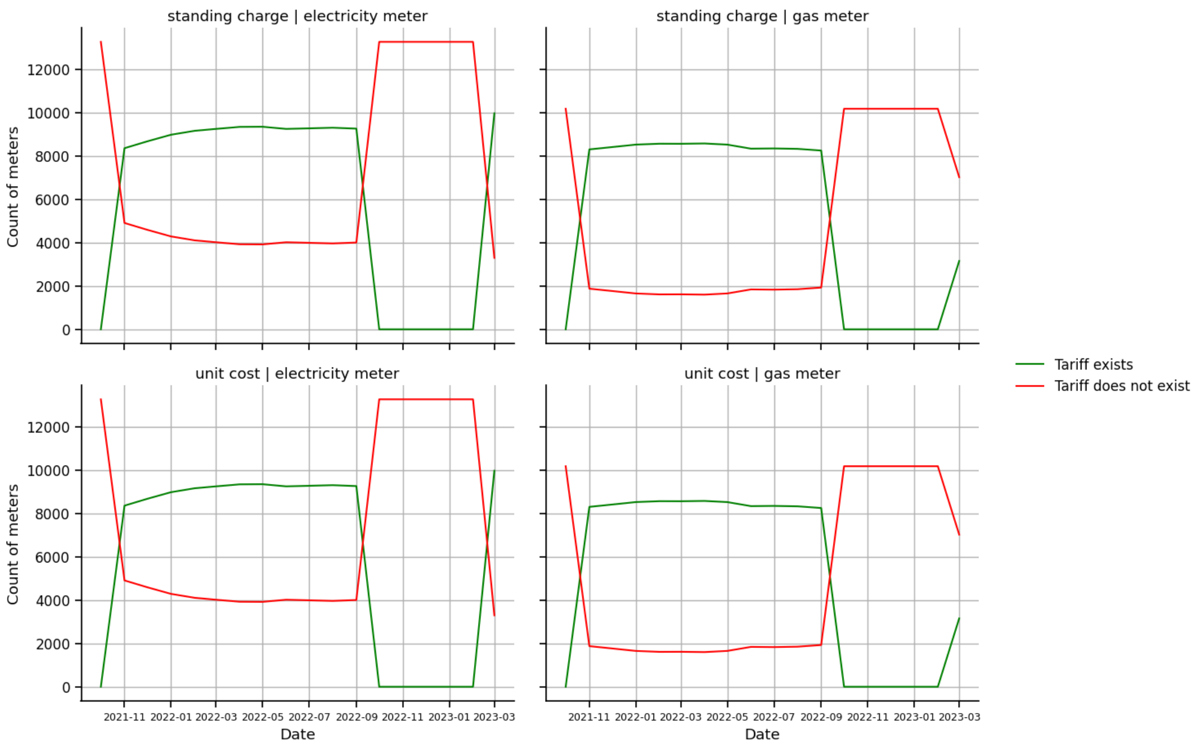

Figure 30 – variation in availability of tariff data over time. For underlying data see: missing_data.csv

The results show distinct regions of missingness over time. First, there appears to be no data for October 2021. This is then followed by a period of relatively stable levels of data availability, with levels of around 63-69% tariff data availability for electricity meters, and 81-84% tariff data availability for gas meters. From October 2022 to February 2023 there is no data availability (due to SERL technical system migration from UKDA to UCL). Then in March 2023 data is available again, at marginally higher levels for electricity meters (around 75% data availability), but substantially reduced levels for gas meters (only around 31%).

Errors (value and parsing)

Next we will consider errors in the tariff data. Here we consider errors associated with a) the value of a variable or b) parsing the data. There are no rules for identifying errors in tariff data or in how to parse the data. The former requires specifying arbitrary thresholds for reasonable values. The latter is complicated because it appears that the exact format in which tariff data appears on the meter can vary dependent on the Energy Supplier responsible for the meter (though note that we do not observe who the Energy Supplier is). Some tariffs are more complicated to parse than others. For example, Block tariffs have a unit cost that varies depending on the amount of energy used. To determine the unit cost therefore requires combining the tariff data with energy consumption data, as well as the dates for when the tariff resets which we do not observe. We have not attempted to parse Block tariffs yet as a result. Note that block tariffs are currently unusual and not prevalent, so this is not a significant omission.

The following shows a breakdown in types of error where tariff data is available (i.e. instances where tariff exists as in the previous plot above).

Table 7. summary of errors in tariff data due to inability to parse data or due to unreasonable values e.g. zeros.

meter_type	**variable**	**valid**	**count**	**percentage**
electricity	standing charge	False	837	0.8%
electricity	standing charge	True	109302	99.2%
electricity	unit cost	False	3636	3.3%
electricity	unit cost	True	107527	97.6%
gas	standing charge	False	1478	1.5%
gas	standing charge	True	94372	98.5%
gas	unit cost	False	16045	16.7%
gas	unit cost	True	79807	83.3%

The results show that, where tariff data is available, errors related to unreasonable values or parsing are low, with valid reads in excess of >97% for all meters and variables except gas unit cost which has 16.7% of readings with errors. The majority of these errors are caused by issues with the ‘scale’ variable e.g. being missing.

Payment status

We are unable to collect payment status information from meters as it is not available to DCC Other Users. It is however important data because:

- payment status affects energy price. Historically households with prepayment meters paid more for energy than households on direct debits.

- households with prepayment meters are considered more likely to be 'energy vulnerable'
- payment status can be used to impute missing tariff data if we assume households are on the Energy Price Cap, or Energy Price Guarantee

We can estimate payment status however in two ways:

1. using data from the cost-of-living crisis survey, which we conducted during winter 22/23[10]
2. using data published by Ofgem or DESNZ about the Energy Price Cap or Energy Price Guarantee, and checking whether household's tariff data matches these data.

The following shows the results of payment status from the cost-of-living crisis survey. This survey was one-off, and so this data is cross-sectional. The counts have been rounded to the nearest 10 to avoid statistical disclosure, and the percentages are calculated using rounded counts and rounded totals.

Cost-of-living crisis survey

The cost-of-living crisis survey has data available for 43.9% of the households where tariff data is available.

meter_type	survey_payment_status	rounded_n	percentage
electricity	Direct debit (including online direct debit)	5440	93.5%
electricity	Don't know	0	0.0%
electricity	Included in rent	0	0.0%
electricity	No response	80	1.4%
electricity	Not applicable / no mains gas	0	0.0%
electricity	Other	20	0.3%
electricity	Payment on receipt of bill (by post, telephone, online or at bank/post office)	230	4.0%
electricity	Pre-payment meter	60	1.0%

[10] Further information and analysis of this survey can be found: Huebner, Gesche, Clare Hanmer, Ellen Zapata-Webborn, Martin Pullinger, Eoghan J. McKenna, Jessica Few, Simon Elam, et al. 2023. "Self-reported Energy Use Behaviour Changed Significantly During the Cost-of-living Crisis in Winter 2022/23: Insights from Cross-sectional and Longitudinal Surveys in Great Britain." SocArXiv. October 6. osf.io/preprints/socarxiv/984yh

gas	Direct debit (including online direct debit)	4840	83.2%
gas	Don’t know	0	0.0%
gas	Included in rent	10	0.2%
gas	No response	330	5.7%
gas	Not applicable / no mains gas	370	6.4%
gas	Other	10	0.2%
gas	Payment on receipt of bill (by post, telephone, online or at bank/post office)	200	3.4%
gas	Pre-payment meter	50	0.9%

The results show that according to the responses of the households who completed the survey, the vast majority of households pay their energy bills by direct debit. 83% for gas and 93% for electricity. Around 3-4% of households are on ‘standard credit’, and around 1% have prepayment meters.

Ofgem’s report ‘Vulnerable consumers in the energy market’ reported prepayment levels of around 15% in England in 2018 for electricity, with higher levels in Wales and Scotland (18%, 19% respectively). For gas prepayment levels in 2018 were 14% for England, 18% for Wales, and 17% for Scotland. Regarding smart meters in particular, DESNZ statistics[11] show that 13% of all smart meters were in prepayment mode at the end of 2022. Clearly, we are considerably under-representing prepayment meter households, at least for those who responded to our cost-of-living crisis survey.

Meters with tariffs matching Energy Price Cap default levels

In order to infer payment status using the published Energy Price Cap or Energy Price Guarantee data, it is necessary to check if the tariff data matches one of the published levels for the relevant time period, region, and meter type. The following shows the results for payment status by matching the tariff data with data for the Energy Price Cap or Energy Price Guarantee. Unlike the survey data, both these data vary longitudinally, and so these results are in the form of a time-series.

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[11] Smart meters in Great Britain, quarterly update December 2022. Department of Energy Security and Net Zero. https://www.gov.uk/government/statistics/smart-meters-in-great-britain-quarterly-update-december-2022

The Energy Price Cap sets default maximum levels for standing charges and unit costs and applied to all consumers on standard variable tariffs up to and including September 2022. From 1st October 2022, the Energy Price Cap continued to apply to standing charges, but the Energy Price Guarantee replaced the Energy Pric Cap for unit costs.

The levels set by the Energy Price Cap were set by Ofgem in periods. The relevant periods for our analysis are:

1. 1 Oct 2021 - 31 Mar 2022
2. 1 Apr 2022 - 30 Sept 2023
3. 1 Oct 2022 - 31 Dec 2022
4. 1 Jan 2023 - 31 Mar 2023

The following plots show, for meters where we have tariff data available, where the relevant tariff variable (standing charge, unit cost) matched the Energy Price Cap for the meter's charge region and date. As tariffs on meters do not specify whether they include VAT or not, we check whether for matches with and without VAT. Note the lack of data for October 2021, and the discontinuity at the right end of the figure between September 2022 and March 2023. These are due to missing data.

The following plots are based on counts that have been rounded to the nearest 10 to avoid statistical disclosure.

Electricity standing charge

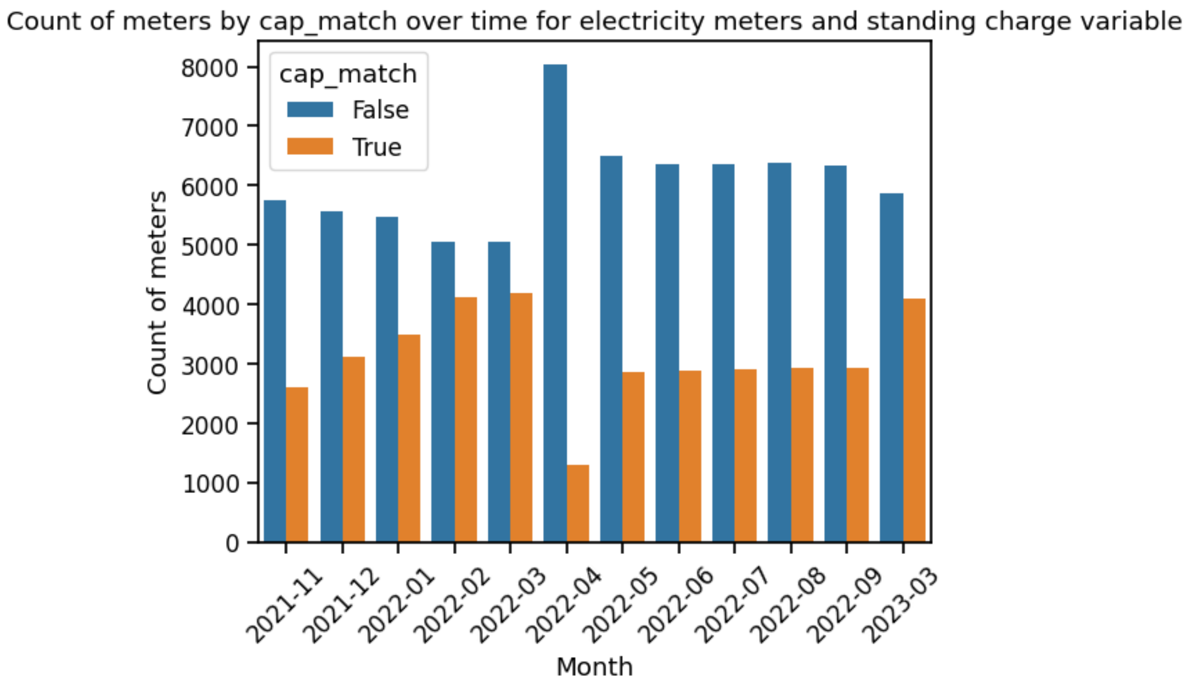

Figure 31. counts of meters where tariff data is available and with electricity standing charge that match the Energy Price Cap. For underlying data see: time_series_count_by_cap_match_electricity_standing charge.csv.

Electricity unit cost

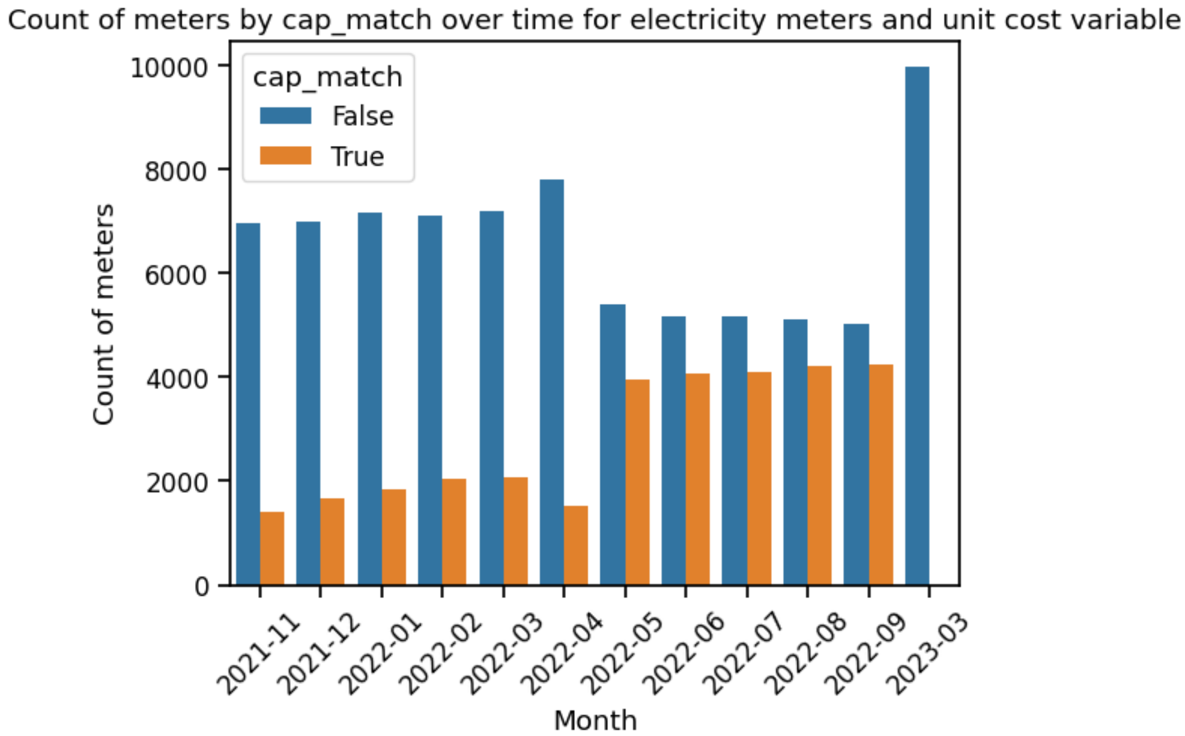

Figure 32. Counts of electricity meters where tariff data is available and with unit costs that match the Energy Price Cap. For underlying data see: time_series_count_by_cap_match_electricity_unit cost.csv

Gas standing charge

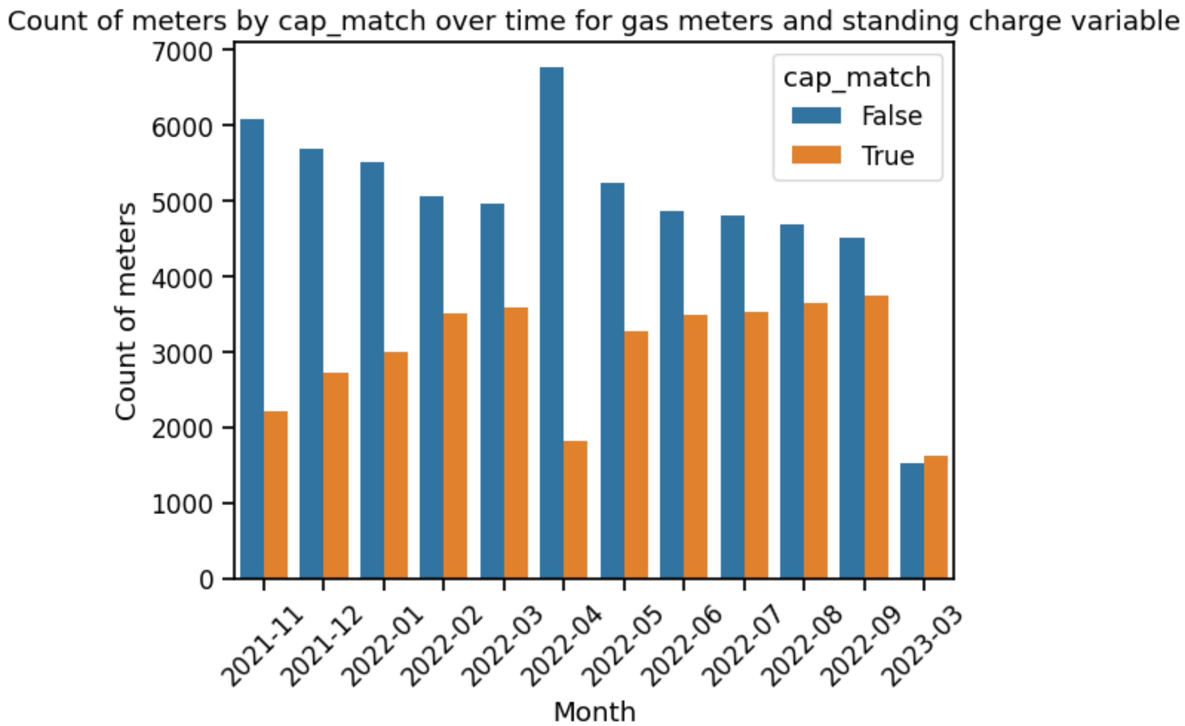

Figure 33. Counts of gas meters where tariff data is available and with standing charge that matches the Energy Price Cap. For underlying data see: time_series_count_by_cap_match_gas_standing charge.csv

Gas unit cost

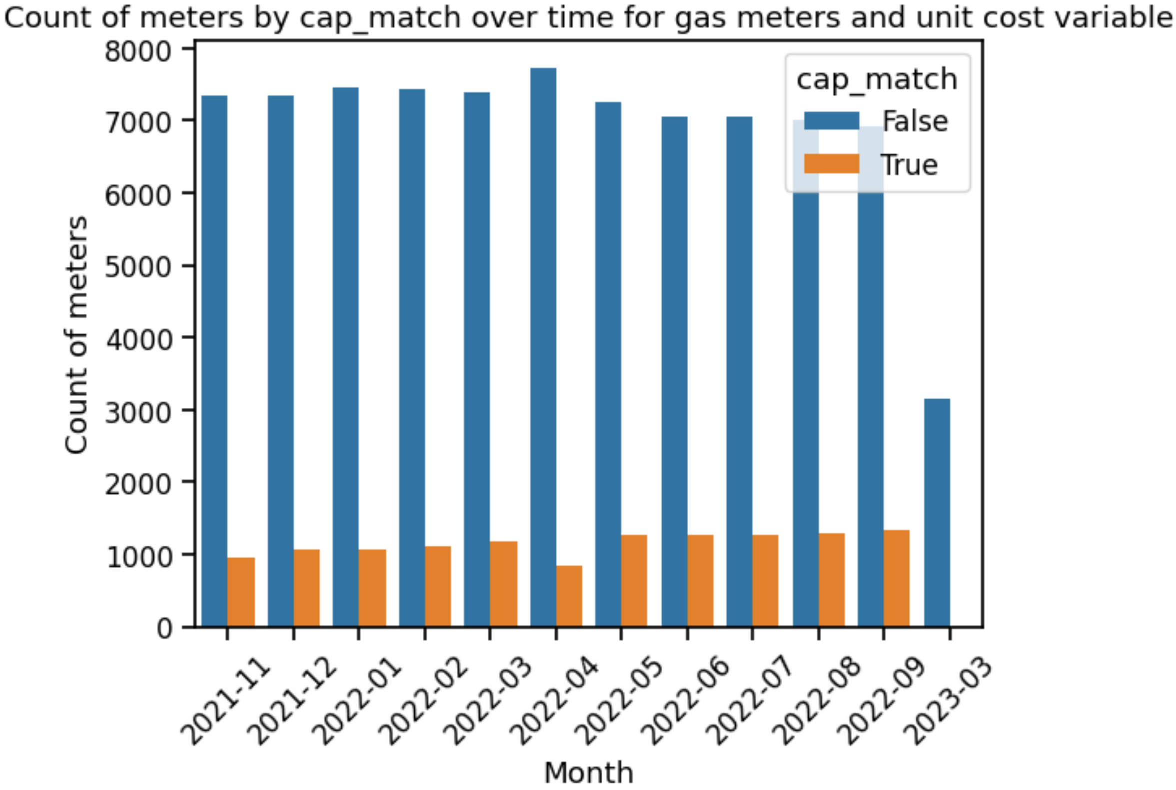

Figure 34. Counts of gas meters where tariff data is available and with unit costs that match the Energy Price Cap. For underlying data see: time_series_count_by_cap_match_gas_unit cost.csv

The results show that, for meters where we have tariff data available:

- a majority of meters do not have a tariff that matches the Energy Price Cap
- a general trend of tariffs on electricity meters having higher levels of matching the Cap than gas meters.
- during the period 1 Oct 2021 - 31 March 2022, low levels of tariff variables matching the Cap at the start of the period (approx 1/4 to 1/3 matching for standing charge for electricity and gas, and lower levels of matching for unit costs ~10-20%), with matching levels rising throughout the period, more so for standing charge than for unit costs. This could be due to steadily rising numbers of consumers finishing fixed term tariffs and going onto standard variable tariffs, or due to delays in Supplier’s updating tariffs on meters.
- during the period 1 Apr 2022 - 31 September: a temporary rise in mismatches in April 2022 across all variables, subsequently dropping back down in May 2022. Presumably this is due to delays in tariffs being updated on meters. Matching levels for gas meters are broadly consistent with the previous period. For electricity meters,

the picture is more mixed, with higher Cap-matching levels than the previous period for unit costs, but lower matching levels for standing charge.

- for the period 1 Oct 2022 onwards: during this period the Energy Price Guarantee came into effect and this applied to unit costs while standing charges remained regulated by the Energy Price Cap, and we only have tariff data for March 2023. The results show that there are no matches with the Energy Price Cap for the unit cost variables, as expected. For standing charges, gas meters showed a big reduction in matches, while electricity meters showed an increase in matches.

Energy Price Guarantee

The Energy Price Guarantee came into effect on 1 October 2022, with changes to default levels that occurred at the same time periods as the Energy Price Cap. As we only have tariff data that overlaps with the Energy Price Guarantee periods during March 2023, the following shows the matches for this month for unit costs only (as standing charges continued to be determined by the Energy Price Cap). Again the figures show matches for meters where tariff data is available, meters with missing tariff data are not included.

Electricity unit cost

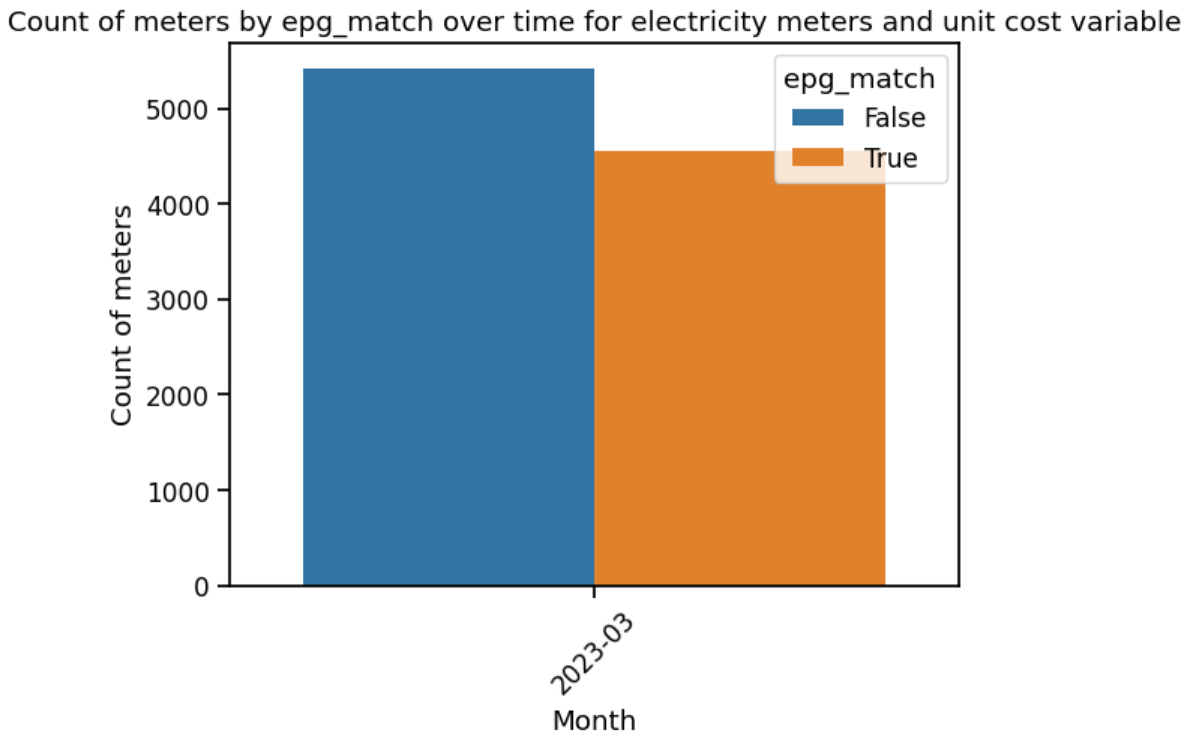

Figure 35. Counts of electricity meters where tariff data is available with unit costs that match the Energy Price Guarantee. For underlying data see: time_series_count_by_epg_match_electricity_unit cost.csv

Gas unit cost

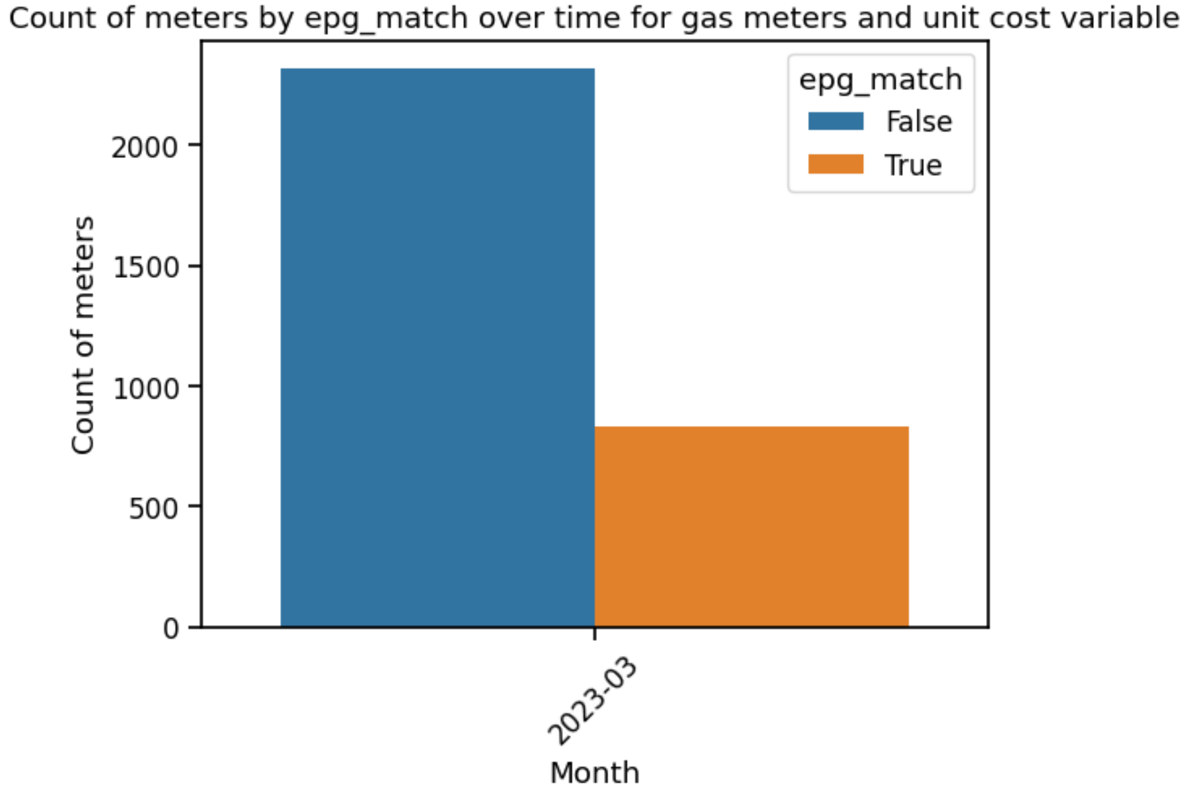

Figure 36. Counts of gas meters where tariff data is available and with unit costs that match the Energy Price Guarantee. For underlying data see: time_series_count_by_epg_match_gas_unit cost.csv

The results show that, for meters where we had tariff data, almost half of the electricity meters matched the Energy Price Guarantee, while only around 1/4 of gas meters matched. For electricity meters, these matching levels were similar to the Cap-matching levels in September 2022. For gas meters, these matching levels are higher than those seen in September 2022 however as there is much higher missing data for gas meters in March 2023 compared to September 2022, the overall numbers of matching meters is reduced.

Comparison of tariff with Energy Price Cap / EPG and how this varies over time

As shown above, the majority of meters do not have tariffs that match the Energy Price Cap nor the Energy Price Guarantee. The question is therefore how much of a difference is there between tariffs on meters and the Cap / Guarantee? In the following, we consider the distribution of differences between tariffs for non-matching meters for three periods: March 2022, September 2022, and March 2023, to assess how the distribution of differences varies over time.

The following shows the difference between the Energy Price Cap standing charge and the standing charge on the meter for meters where we have tariff, but it doesn't match the Cap. The Energy Price Cap value is estimated using the meter's charge region and payment status given the cost of living crisis survey response, or assumed 'other' payment status if no survey response.

Values have been converted to annual equivalents, using Ofgem's assumed 'typical' annual consumption values for unit costs.

Note that comparison is complicated because while Energy Price Cap / EPG tariff levels are published as excluding VAT, tariffs on meters do not include information about whether the tariff includes VAT or not. For the purposes of the following plots we assume the tariff on the meter includes VAT, as analysis included below indicates this is the norm, and therefore convert the Energy Price Cap / EPG rates to values including VAT.

Finally note that we do not observe if meters are on fixed tariffs or variable tariffs. There will be some meters on fixed tariffs and these will have tariffs that are lower than the Energy Price Cap, and so when comparing the distribution of tariffs on meters with the Energy Price Cap we would expect that the average of the distribution to be lower than the Cap.

All counts have been rounded to the nearest 10 to avoid statistical disclosure.

March 2022 - Difference with Energy Price Cap

Electricity standing charge

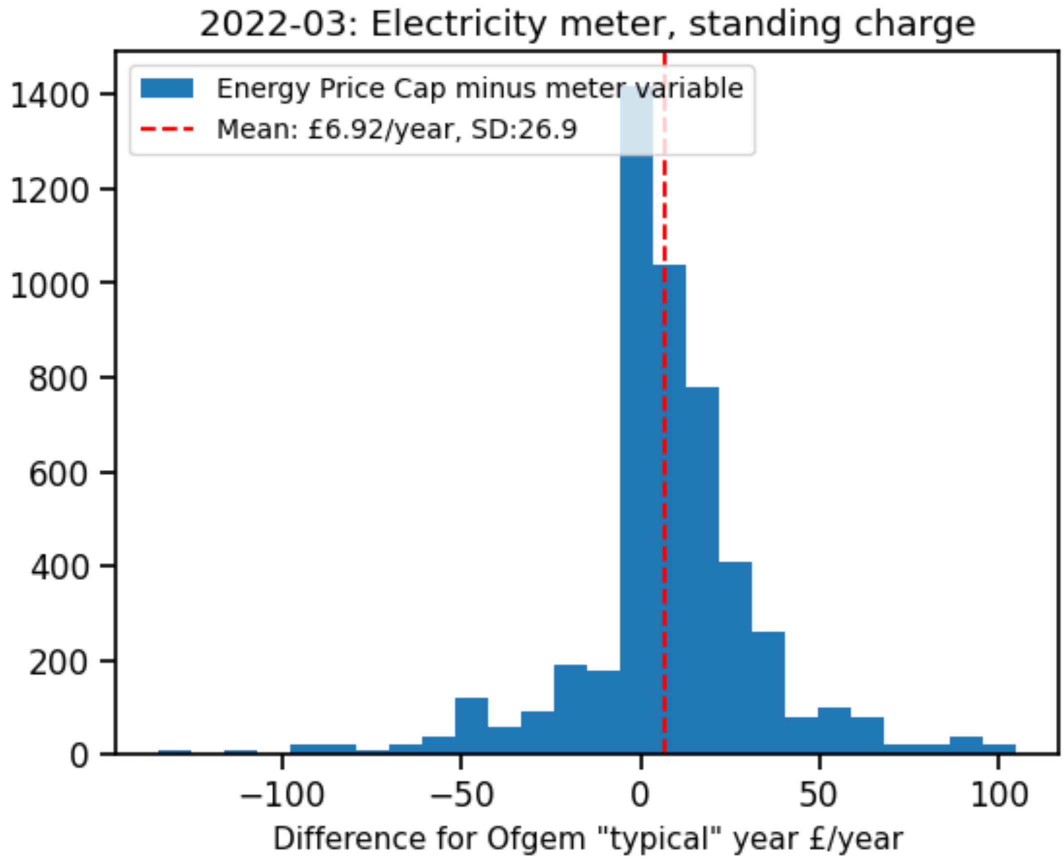

Figure 37. Histogram of the difference between the relevant Energy Price Cap and the standing charge on electricity meters where tariff data is available but where the standing charge does not match the Energy Price Cap. For underlying data see: compare_cap_with_meter_2022-03_electricity_standing charge.csv

Electricity unit cost

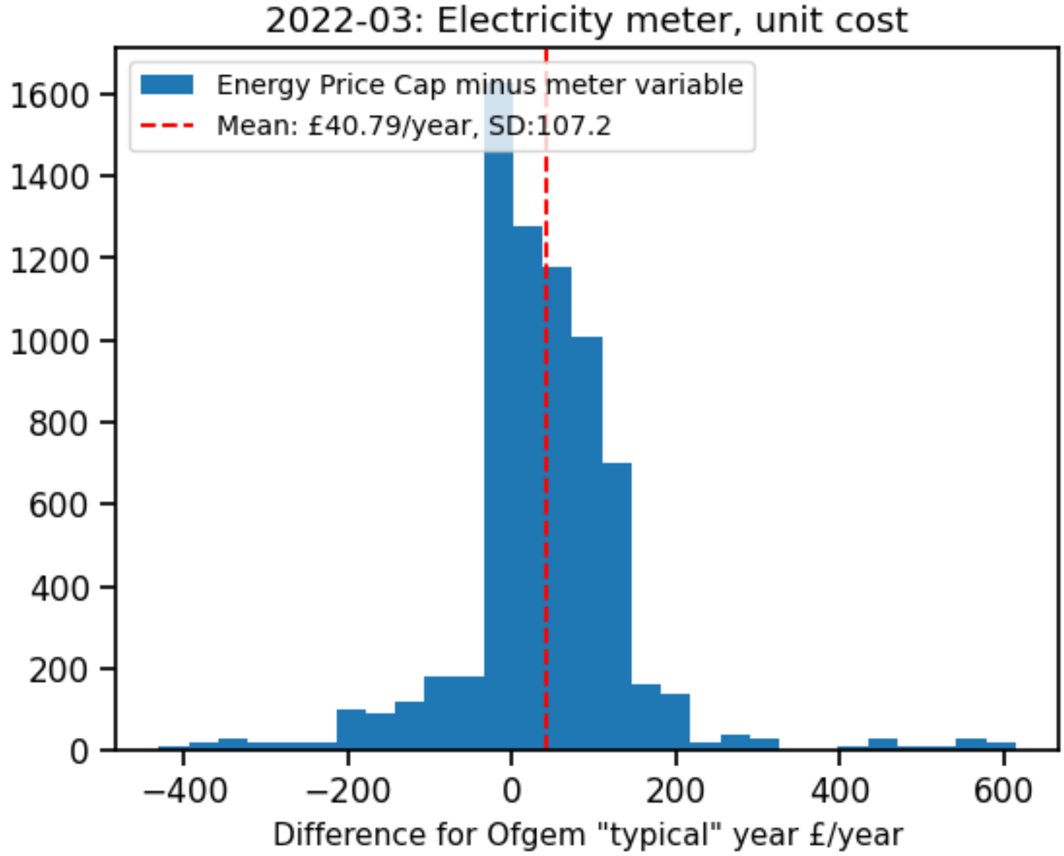

Figure 38. Histogram of the difference between the relevant Energy Price Cap and the unit cost on electricity meters where tariff data is available but where the unit cost does not match the Energy Price Cap. For underlying data see: compare_cap_with_meter_2022-03_electricity_unit cost.csv

Gas standing charge

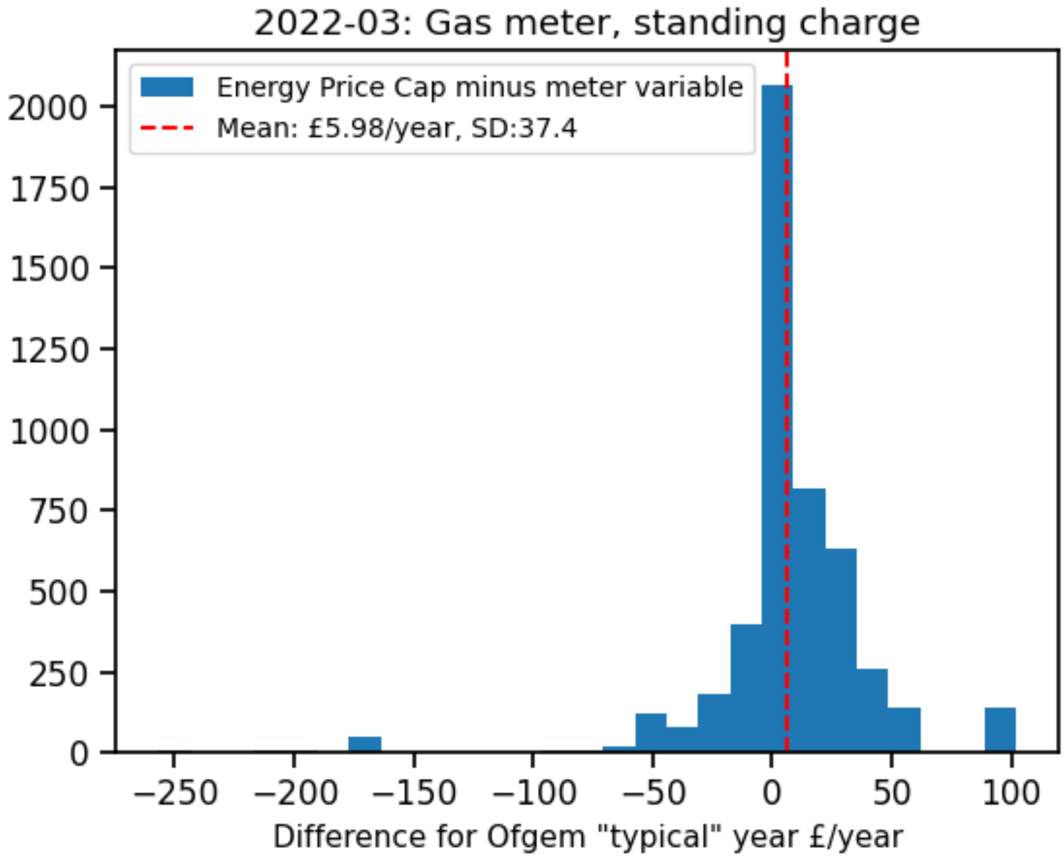

Figure 39. Histogram of the difference between the relevant Energy Price Cap and the standing charge on gas meters where tariff data is available but where the standing charge does not match the Energy Price Cap. For underlying data see: compare_cap_with_meter_2022-03_gas_standing charge.csv

Gas unit cost

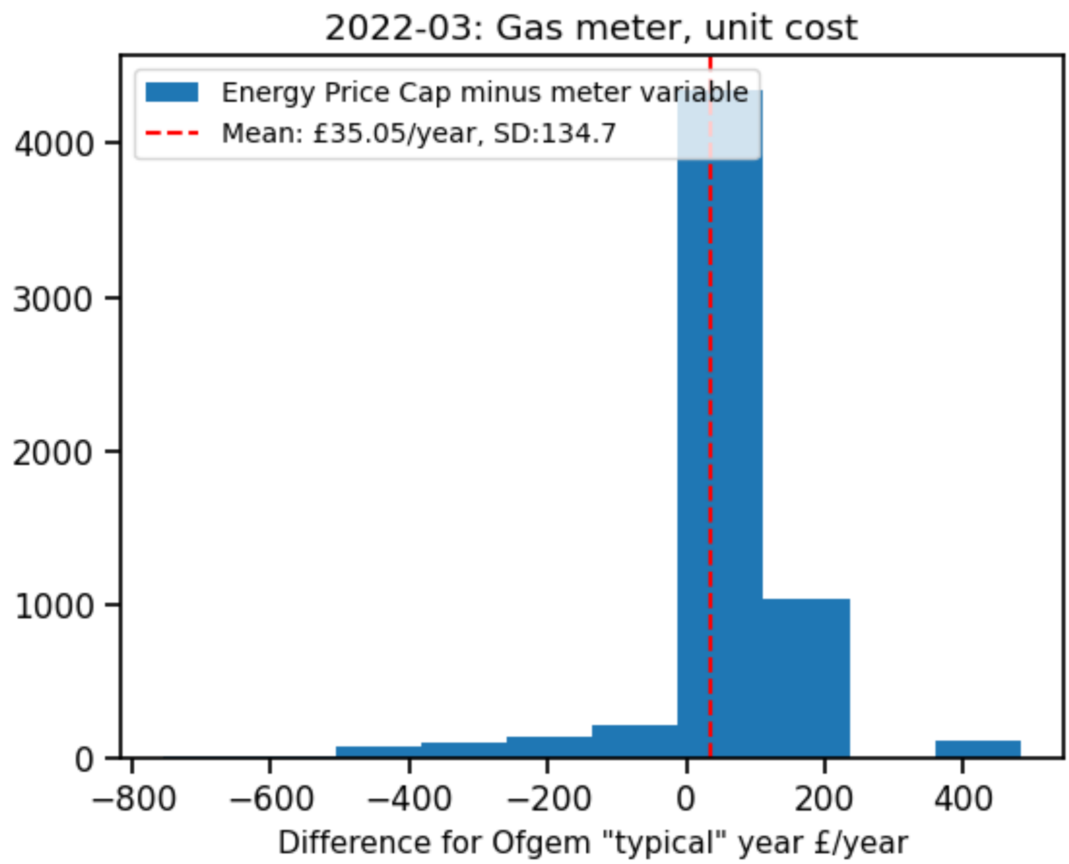

Figure 40. Histogram of the difference between the relevant Energy Price Cap and the unit cost on gas meters where tariff data is available but where the unit cost does not match the Energy Price Cap. For underlying data see: compare_cap_with_meter_2022-03_gas_unit cost.csv

For the period March 2022, for meters with tariffs that do not match the Energy Price Cap during this period, the results show that for electricity the mean difference of almost £7/year for standing charge and £40/year for the unit cost (assuming Ofgem typical annual electricity consumption values of 2700 kWh).

The mean difference for gas standing charge was almost £6/year and for unit cost around £35/year (assuming Ofgem typical annual gas consumption of 11500 kWh).

This means that on average the tariffs on the meter were lower than those on the Energy Price Cap. These lower tariffs could be explained if these households were on fixed tariffs. This will be true for some households and so this is an explanation for the results however we do not know the extent to which it explains the results.

Considering the distribution of differences, the results show that a difference near zero is the most common, indicating that these meters could actually have tariffs that are on the Energy Price Cap but there is some small difference in the exact value on the meter which means it is not an exact match to the published values (we match on a float precision of at least 3).

There is however considerable spread with some meters with tariffs that result in energy bills that are considerably higher than the Energy Price Cap (indicated on histograms by counts in bins where the difference with the Cap is negative). For electricity meters the standard deviation is around £27/year for standing charge, and over £100/year for unit cost. For gas meters the standard deviation is larger at £37/year for standing charge and £135/year for unit cost.

September 2023 - Difference with the Energy Price Cap

Electricity standing charge

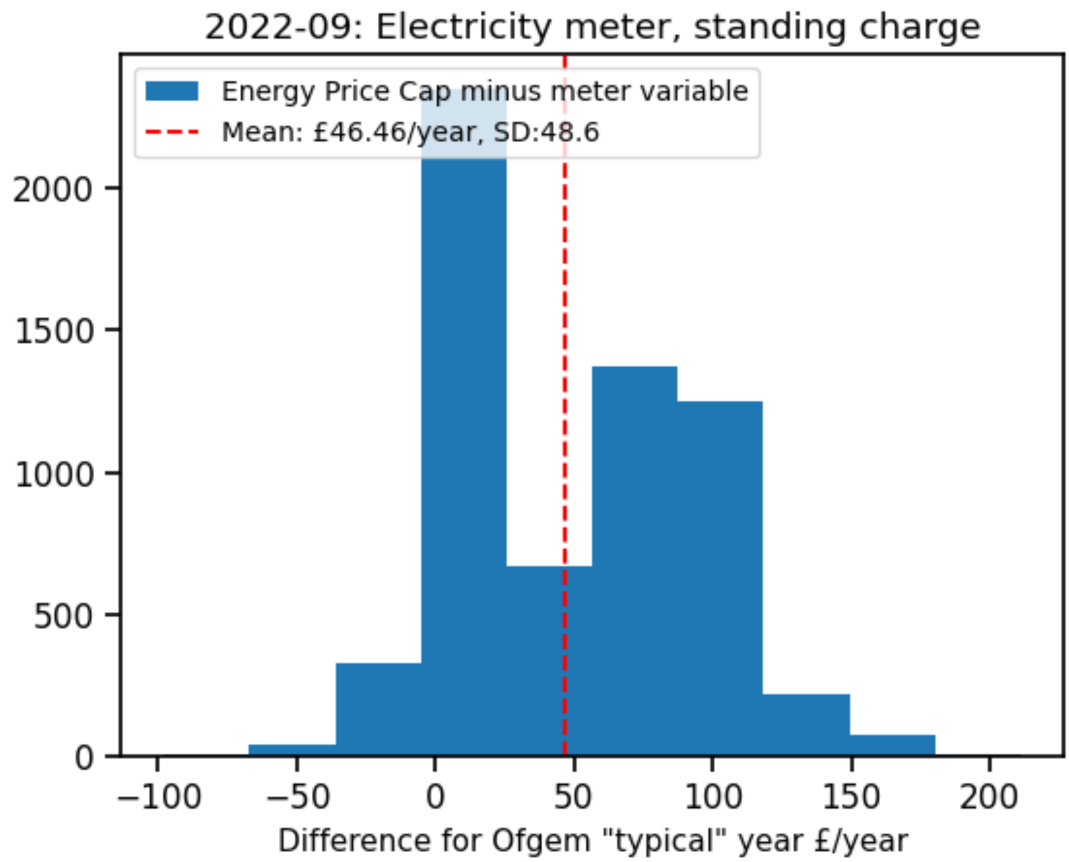

Figure 41. Histogram of the difference between the relevant Energy Price Cap and the standing charge on electricity meters where tariff data is available but where the standing charge does not match the Energy Price Cap. For underlying data see: compare_cap_with_meter_2022-09_electricity_standing charge.csv

Electricity unit cost

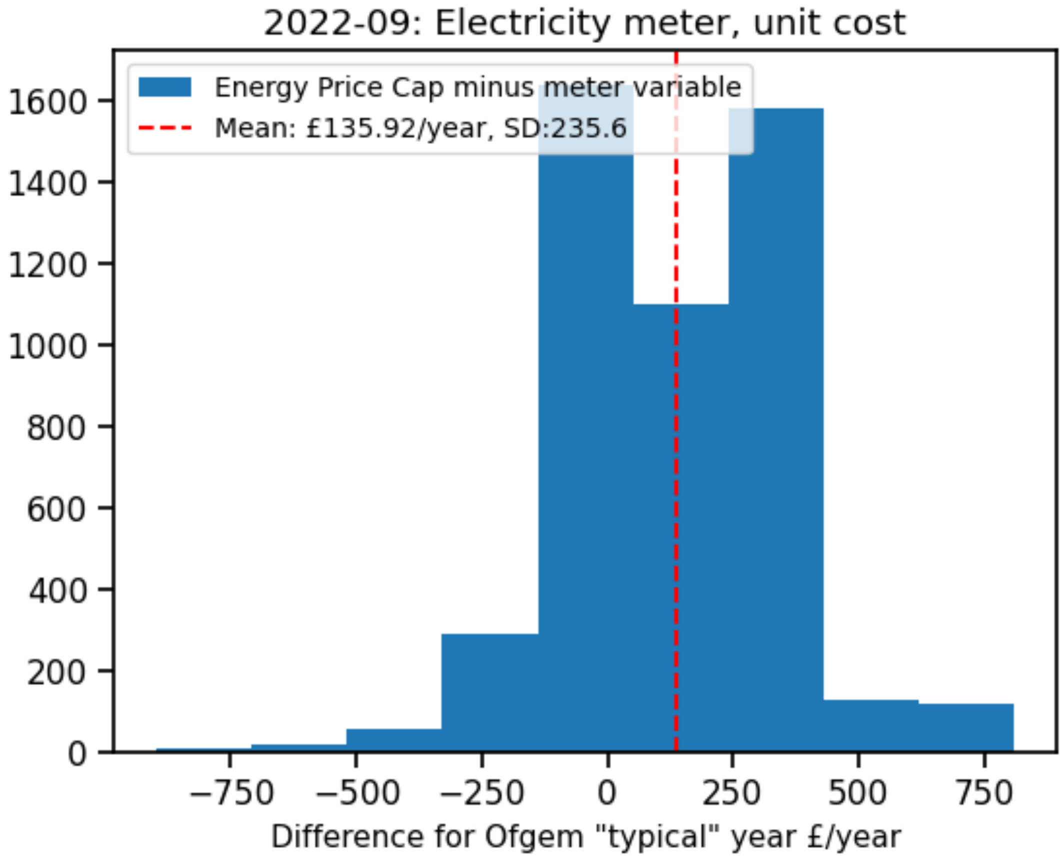

Figure 42. Histogram of the difference between the relevant Energy Price Cap and the unit cost on electricity meters where tariff data is available but where the unit cost does not match the Energy Price Cap. For underlying data see: compare_cap_with_meter_2022-09_electricity_unit cost.csv

Gas standing charge

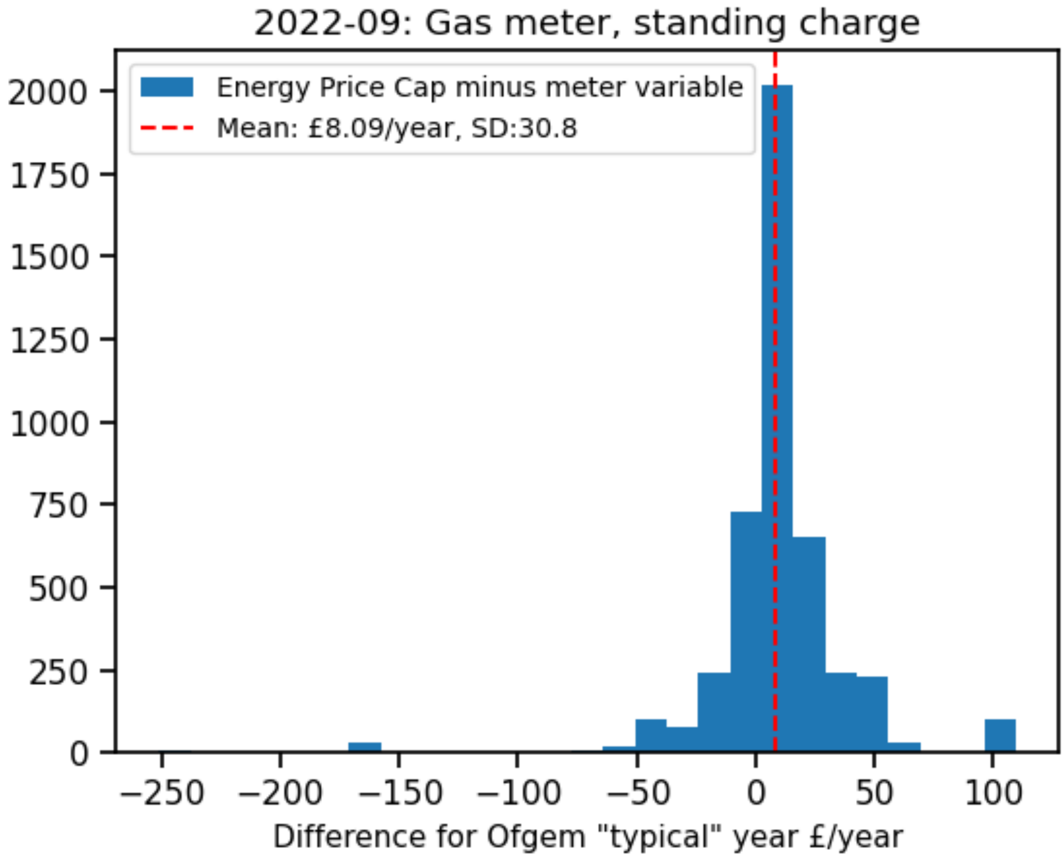

Figure 43. Histogram of the difference between the relevant Energy Price Cap and the standing charge on gas meters where tariff data is available but where the standing charge does not match the Energy Price Cap. For underlying data see: compare_cap_with_meter_2022-09_gas_standing charge.csv

Gas unit cost

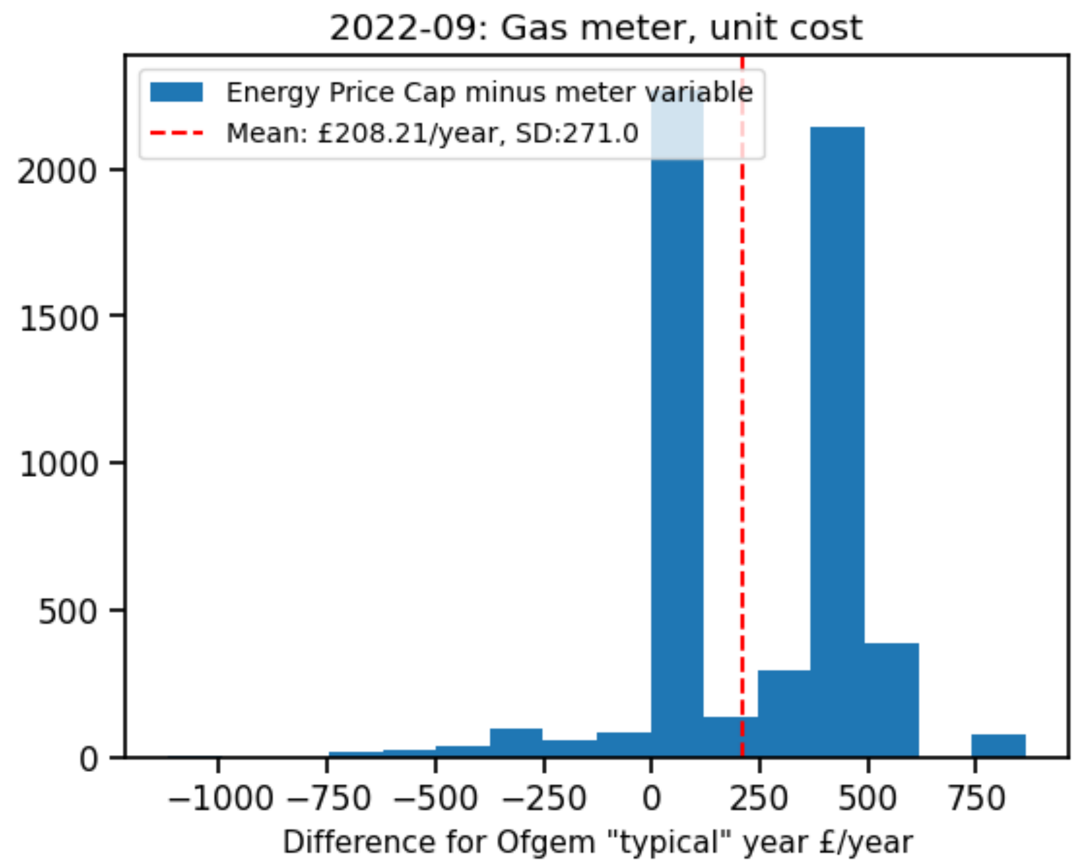

Figure 44. Histogram of the difference between the relevant Energy Price Cap and the unit cost on gas meters where tariff data is available but where the unit cost does not match the Energy Price Cap. For underlying data see: compare_cap_with_meter_2022-09_gas_unit cost.csv

Considering the period September 2022, this was the last month before the Energy Price Guarantee was introduced. Compared to March 2022, energy prices were higher. The results show that in September 2022 the average difference increased compared to March 2022 for all meters and variables. This means that for these meters (with tariffs that do not match the Energy Price Cap) on average their tariff had lower energy prices than the Energy Price Cap.

The average differences were: £46/year and £136/year for electricity standing charge and unit cost respectively, and £8/year and £208/year for gas standing charge and unit cost respectively.

Bimodal distributions are apparent for gas unit cost, electricity unit cost and standing charge, with one peak around zero and another around a positive value (i.e. tariff on meter lower than Energy Price Cap). The former peak around zero suggests a relatively trivial mismatch indicating that these meters have tariffs that are changing in line with the Energy Price Cap but have some small difference that confounds the matching process used.

The latter peak could be explained if the tariff on the meters is not being updated, or the meters are on a fixed tariff.

March 2023 - Difference with Energy Price Guarantee

Electricity standing charge

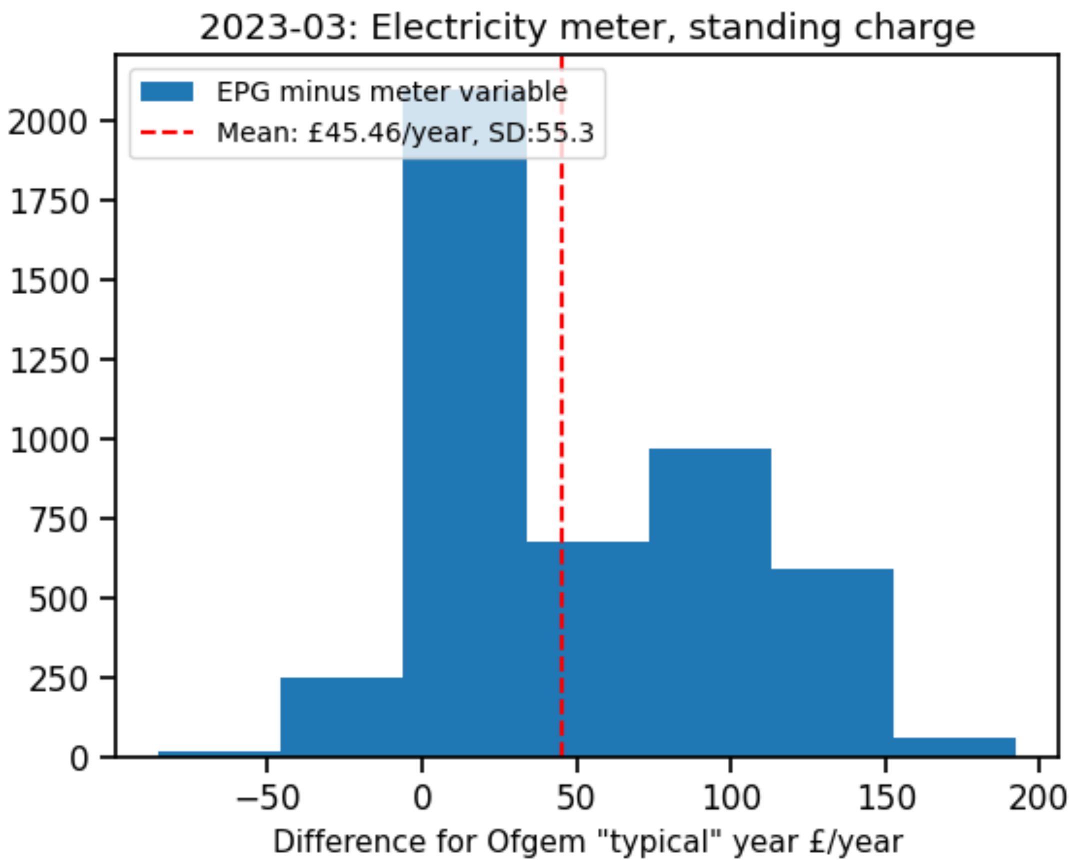

Figure 45. Histogram of the difference between the relevant Energy Price Guarantee and the standing charge on electricity meters where tariff data is available but where the standing charge does not match the Energy Price Guarantee. For underlying data see: compare_epg_with_meter_2023-03_electricity_standing charge.csv

Electricity unit cost

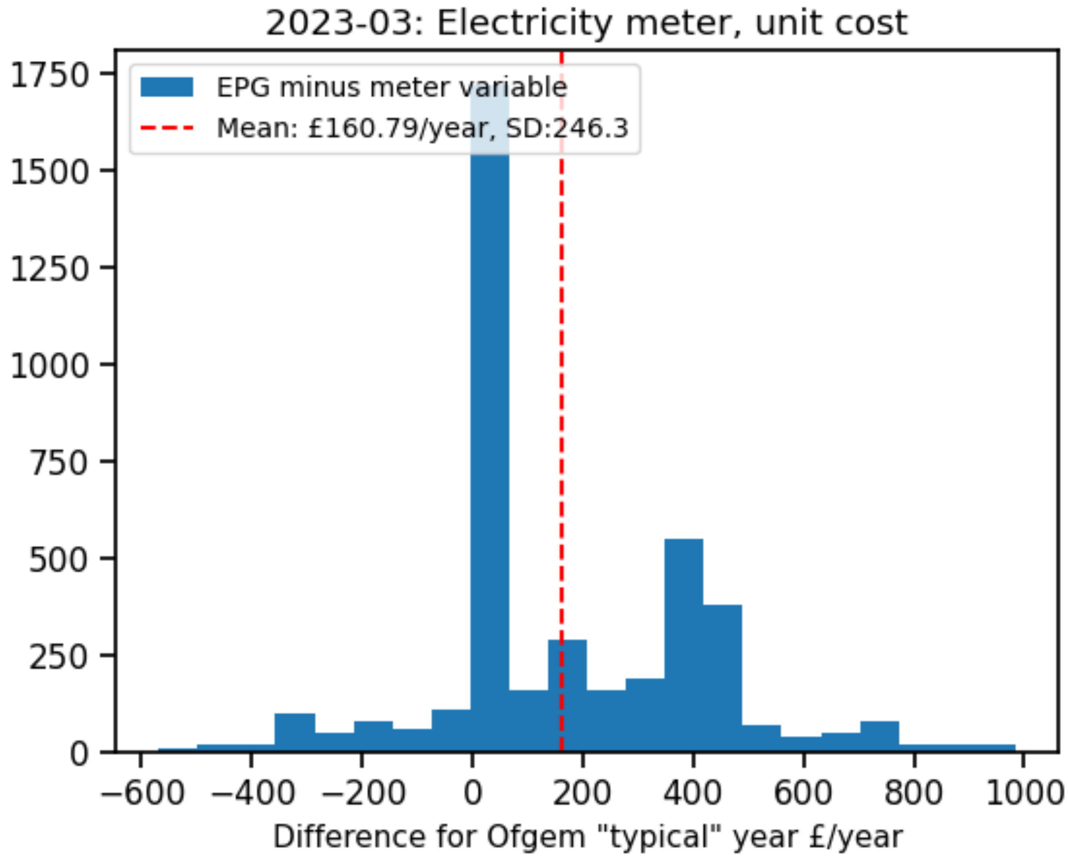

Figure 46. Histogram of the difference between the relevant Energy Price Guarantee and the unit cost on electricity meters where tariff data is available but where the unit cost does not match the Energy Price Guarantee. For underlying data see: compare_epg_with_meter_2023-03_electricity_unit cost.csv

Gas standing charge

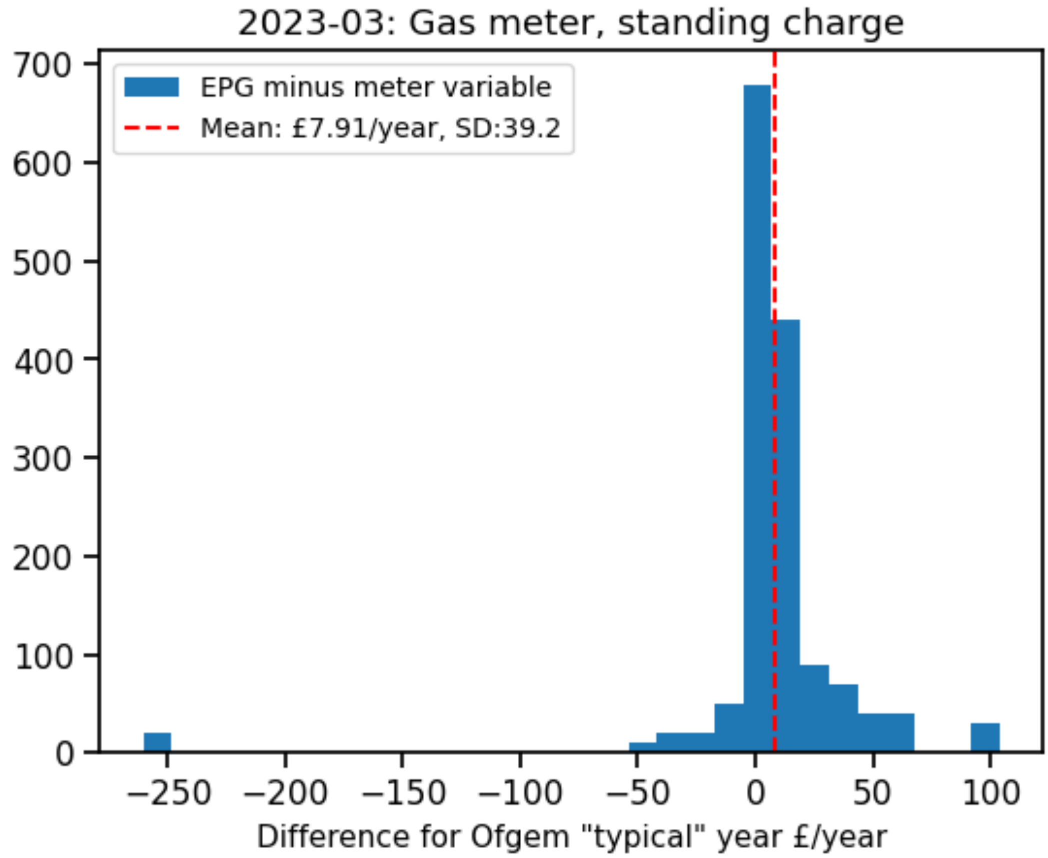

Figure 47. Histogram of the difference between the relevant Energy Price Guarantee and the standing charge on gas meters where tariff data is available but where the standing charge does not match the Energy Price Guarantee. For underlying data see: compare_epg_with_meter_2023-03_gas_standing charge.csv

Gas unit cost

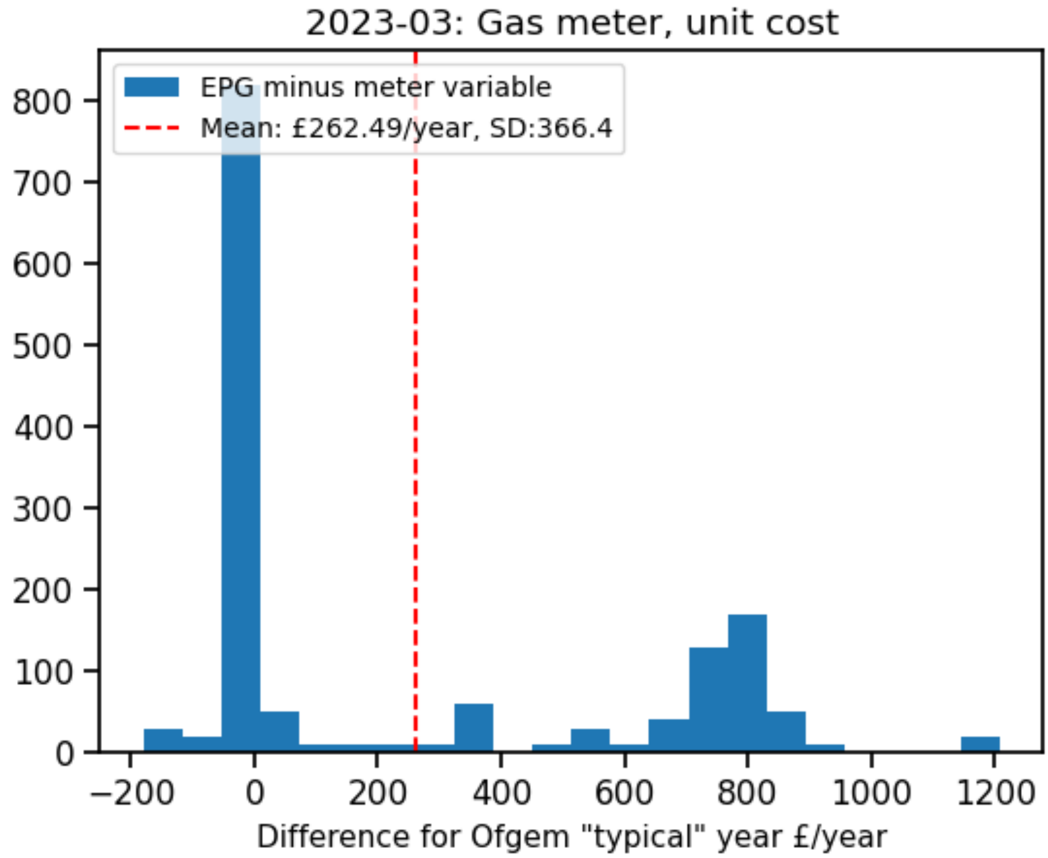

Figure 48. Histogram of the difference between the relevant Energy Price Guarantee and the unit cost on gas meters where tariff data is available but where the unit cost does not match the Energy Price Guarantee. For underlying data see: compare_epg_with_meter_2023-03_gas_unit cost.csv

Energy prices increased with the Energy Price Guarantee. In the period March 2023, the EPG had been in effect for six months. The results show that, for meters with tariffs that do not match the EPG, for electricity meters the standing charge on the meter was lower than the EPG by an average of £45/year. For unit cost, the tariffs on electricity meters were lower than the EPG by an average of £161/year.

Gas meters showed a similar trend, with standing charges on meters lower than the EPG by an average of 8/year, and unit costs lower by an average of £262/year.

The distributions of unit costs for both gas and electricity show that a difference of close to zero is most common, indicating small differences with the EPG. They both also have a further distributions of large positive values, around £750 for gas and £500 for electricity, meaning the EPG rates are higher than those on the meter. These could be caused by meters that have not had their tariff changed, or meters on fixed tariffs.

Similar to unit costs, the distributions for standing changes also show a difference of near zero to be most common, and with significant proportions of meters with tariffs that are lower than the EPG.

Meters with tariffs that do not change

Some of the patterns shown in the results above could be explained by meters that were not being updated. Anecdotally we understand that energy suppliers may not update tariffs on meters for customers that are on dynamic time-of-use tariffs. However presumably this should apply to electricity meters only, and to the unit cost variable, not the standing charge.

The following shows the numbers and percentages of meters which have tariff variables that are unchanged between March 2022 and March 2023, described by the boolean variable no_change_flag. Counts, totals and percentages use values rounded to the nearest 10 to avoid statistical disclosure.

Table 8. Summary of counts and percentages of meters with tariff components that do not vary between March 2022 and March 2023 (indicated by the Boolean no_change_flag).

meter_type	variable	no_change_flag	rounded_n	percentage
electricity	standing charge	False	12140	91.6%
electricity	standing charge	True	1120	8.4%
electricity	unit cost	False	12200	92.0%
electricity	unit cost	True	1070	8.1%
gas	standing charge	False	9550	93.9%
gas	standing charge	True	630	6.2%
gas	unit cost	False	9750	95.9%
gas	unit cost	True	420	4.1%

The results show 8.4% of electricity meters has standing charges that did not change between March 2022 and March 2023 and 6.2% for standing charges on gas meters. For unit costs the percentage of electricity meters without a change is 8.1% and 4.1% for gas. Electricity meters show higher levels of unchanged tariffs than gas meters.

It is not clear what is the cause of tariffs on meters not changing, and whether these are valid tariffs or not. Going forward we will exclude these meters with unchanging tariffs for the analysis that follows.

Does the tariff on meters include VAT?

While the energy prices for the Energy Price Cap and Energy Price Guarantee are published with information about whether they include VAT or not, the tariffs on meters do not have this information. We can however compare the tariffs on the meters with the published prices with and without VAT, to identify whether tariffs on meters include VAT or not.

The following shows the numbers and percentages of meters with tariffs that match the Energy Price Cap and whether the match indicates that the tariff on the meter includes VAT or not. Counts, totals, and percentages are based on values rounded to nearest 10 to avoid statistical disclosure.

Table 9. Summary of counts and percentages of tariff components that include VAT or not inferred from matching to Energy Price Cap levels.

meter_type	variable	cap_tariff_includes_vat	rounded_n	percentage
electricity	standing charge	False	0	0.0%
electricity	standing charge	True	6980	100.0%
electricity	unit cost	False	0	0.0%
electricity	unit cost	True	5060	100.0%
gas	standing charge	False	20	0.3%
gas	standing charge	True	5830	99.8%
gas	unit cost	False	140	5.9%
gas	unit cost	True	2260	95.0%

And the following shows the same but for the Energy Price Guarantee.

Table 10. Summary of counts and percentages of tariff components that include VAT or not inferred from matching to the Energy Price Guarantee levels.

meter_type	variable	epg_tariff_includes_vat	rounded_n	percentage
electricity	standing charge	True	4100	100.0%
electricity	unit cost	False	150	3.3%
electricity	unit cost	True	4400	96.7%
gas	standing charge	True	1630	100.0%
gas	unit cost	False	350	42.2%

gas	unit cost	True	480	57.8%

The results show that when comparing tariffs to the Energy Price Cap, for electricity meters practically 100% of the tariffs on meters do include VAT. For gas meters, the results show that over 99% of the standing charges on meters includes VAT, but that there is a small percentage of around 6% of gas meters that have unit costs that do not appear to include VAT.

When comparing to the EPG, the results are similar for electricity, though a small percentage percentage (3%) of meters appear to have unit costs that do not include VAT.

For gas meters, all meters appear to have standing charges that include VAT, but 42% appear to have unit costs that do not include VAT.

The results suggest therefore that:

- for standing charges nearly all meters include VAT
- for unit costs, nearly all electricity meters include VAT
- for unit costs, some gas meters do not include VAT, with the proportion increasing from around 6% to 42% after the Energy Price Guarantee came into effect.

Imputed tariff and payment status data

Because of the issue of missing data, we impute or replace missing data with substituted values using a range of rules.

Imputation rules

The following describes the rules that were used to impute missing tariff data and estimate payment status.

Q4 2022 / Q1 2023

The Energy Price Guarantee (EPG) is in effect during this period. Tariff data is only available during March 2023.

- Rule 1: if the tariff on the meter matches the EPG for the relevant region in March 2023, then the payment status is given by the relevant match, and missing tariff data for the rest of this period is imputed using the EPG levels.
- Rule 2: if there is no tariff on the meter in March 2023, and if payment status is reported in the cost-of-living crisis survey, then missing tariff data is imputed using EPG levels for the relevant region and for the payment status given by the cost-of-living crisis survey.

- Rule 3: if there is tariff on the meter in March 2023 but this does not match the EPG for the relevant region, then assume a fixed tariff and missing tariff data is imputed to be equal to the tariff in March 2023. Payment status is assumed to be ‘unknown (not prepayment)’.
- Rule 4: if no tariff data in March 2023, and no payment status from cost-of-living crisis survey, then assume payment status is ‘other’ and missing tariff data imputed to be EPG level for other payment type for relevant region.

Q4 2021 / Q1 2022

The Energy Price Cap (‘Cap’) is in effect during this period.

- Rule 5: if tariff data is missing for a given month, and the tariff on the meter matches the Cap for at least one month during this period, then the missing tariff data is imputed by the appropriate Cap level and matching payment status.
- Rule 6: if tariff data is missing for a given month, and there are no matches with the Cap during this period, and if there is payment status given by the cost-of-living crisis survey, then missing tariff data for this month is imputed by the Cap level for the relevant region and using the payment status given by the survey.
- Rule 7: if tariff data is missing for a given month, and there are no matches with the Cap during this period, and if there is no payment status given by the cost-of-living crisis survey, then if there is tariff data available for March 2022, then missing tariff data for this month is imputed by the tariff data available for March 2022 and the meter is assumed to be on a fixed tariff. Payment status is assumed to be ‘unknown (not prepayment)’.
- Rule 8: if tariff data is missing for a given month, and there are no matches with the Cap during this period, and if there is no payment status given by the cost-of-living crisis survey, and if there is no tariff data available for March 2022, then if payment status is assumed to be ‘other’ and missing tariff data imputed by the Cap for other payment status for the relevant region.
- Rule 9: if tariff data is not missing for a given month, and this matches a Cap level for the relevant region, then payment status is given by the relevant matching Cap payment status.
- Rule 10: if tariff data is not missing for a given month, but tariff does not match the Cap, and if there is no payment status from the survey, then assume fixed tariff, and payment status is assumed to be ‘not prepayment’.
- Rule 17: if tariff data is not missing for a given month, but this matches multiple Cap levels for the relevant region with multiple payment statuses, then if payment status is

available from cost-of-living crisis, then payment status is given by survey payment status.

Q2 2022/ Q3 2022

This is the summer period of 2022, and the Energy Price Cap was in effect. The rules are similar to those above for the period Q4 2021 / Q1 2022

- Rule 11: if tariff data is missing for a given month, and the tariff on the meter matches the Cap for at least one month during this period, then the missing tariff data is imputed by the appropriate Cap level and matching payment status.
- Rule 12: if tariff data is missing for a given month, and there are no matches with the Cap during this period, and if there is payment status given by the cost-of-living crisis survey, then missing tariff data for this month is imputed by the Cap level for the relevant region and using the payment status given by the survey.
- Rule 13: if tariff data is missing for a given month, and there are no matches with the Cap during this period, and if there is no payment status given by the cost-of-living crisis survey, then if there is tariff data available for September 2022, then missing tariff data for this month is imputed by the tariff data available for September 2022 and the meter is assumed to be on a fixed tariff. Payment status is assumed to be ‘unknown (not prepayment)’.
- Rule 14: if tariff data is missing for a given month, and there are no matches with the Cap during this period, and if there is no payment status given by the cost-of-living crisis survey, and if there is no tariff data available for September 2022, then if payment status is assumed to be ‘other’ and missing tariff data imputed by the Cap for other payment status for the relevant region.
- Rule 15: if tariff data is not missing for a given month, and this matches a Cap level for the relevant region, then payment status is given by the relevant matching Cap payment status.
- Rule 16: if tariff data is not missing for a given month, but tariff does not match the Cap, and if there is no payment status from the survey, then assume fixed tariff, and payment status is assumed to be ‘not prepayment’
- Rule 18: if tariff data is not missing for a given month, but this matches multiple Cap levels for the relevant region with multiple payment statuses, then if payment status is available from cost-of-living crisis, then payment status is given by survey payment status.

The following table summarises the counts and proportion of data imputed using the various imputation rules. Counts and percentages are based on values rounded to nearest 10.

Table 11. Summary of percentages of tariff data imputed by the various imputation rules.

imputation_rule	rounded_n	percentage
rule1	66700	8.5%
rule2	55960	7.1%
rule3	51230	6.5%
rule4	87950	11.2%
rule5	16280	2.1%
rule6	35600	4.5%
rule7	12990	1.7%
rule8	45570	5.8%
rule9	44670	5.7%
rule10	106600	13.6%
rule17	130	0.0%
rule11	5140	0.7%
rule12	22780	2.9%
rule13	1750	0.2%
rule14	46430	5.9%
rule15	62770	8.0%
rule16	121440	15.5%
rule18	1530	0.2%

Payment status (imputed)

The following shows the breakdown of payment statuses at various moments in time (March 2022, September 2022, and March 2023) for the different tariff components based on the imputation rules. Counts and percentages are based on values rounded to the nearest 10 to avoid statistical disclosure.

March 2022

Table 12. Counts and percentages of payment status (imputed from imputation rules) for different meters and tariff components in March 2022.

meter_type	variable	imputed_payment_status	rounded_n	percentage
electricity	standing charge	Not prepayment as assumed fixed tariff	4210	34.7%
electricity	standing charge	other	7250	59.8%
electricity	standing charge	prepayment	110	0.9%
electricity	standing charge	standard credit	560	4.6%
electricity	unit cost	Not prepayment as assumed fixed tariff	6080	49.8%
electricity	unit cost	other	5450	44.7%
electricity	unit cost	prepayment	130	1.1%
electricity	unit cost	standard credit	540	4.4%
gas	standing charge	Not prepayment as assumed fixed tariff	4440	46.5%
gas	standing charge	other	4520	47.4%
gas	standing charge	prepayment	110	1.2%
gas	standing charge	standard credit	470	4.9%
gas	unit cost	Not prepayment as assumed fixed tariff	5690	58.4%
gas	unit cost	Other payment type, Prepayment meter	0	0.0%
gas	unit cost	other	3160	32.4%

gas	unit cost	prepayment	420	4.3%
gas	unit cost	standard credit	480	34.7%

September 2022

Table 13. Counts and percentages of payment status (imputed from imputation rules) for different meters and tariff components in September 2022.

meter_type	variable	imputed_payment_status	rounded_n	percentage
electricity	standing charge	Not prepayment as assumed fixed tariff	5290	43.5%
electricity	standing charge	other	6390	52.6%
electricity	standing charge	prepayment	120	1.0%
electricity	standing charge	standard credit	350	2.9%
electricity	unit cost	Not prepayment as assumed fixed tariff	3980	32.6%
electricity	unit cost	other	7510	61.6%
electricity	unit cost	prepayment	160	1.3%
electricity	unit cost	standard credit	550	4.5%
gas	standing charge	Not prepayment as assumed fixed tariff	3910	41.0%
gas	standing charge	other	5130	53.8%
gas	standing charge	prepayment	120	1.3%
gas	standing charge	standard credit	380	4.0%
gas	unit cost	Not prepayment as assumed fixed tariff	5280	54.2%

gas	unit cost	Other payment type, Prepayment meter	20	0.2%
gas	unit cost	other	4040	41.4%
gas	unit cost	prepayment	60	0.6%
gas	unit cost	standard credit	350	3.6%

March 2023

Table 14. Counts and percentages of payment status (imputed from imputation rules) for different meters and tariff components in March 2023.

meter_type	variable	imputed_payment_status	rounded_n	percentage
electricity	standing charge	Not prepayment as assumed fixed tariff	3530	29.1%
electricity	standing charge	other	8160	67.2%
electricity	standing charge	prepayment	130	1.1%
electricity	standing charge	standard credit	330	2.7%
electricity	unit cost	Not prepayment as assumed fixed tariff	3100	25.4%
electricity	unit cost	other	8600	70.5%
electricity	unit cost	prepayment	120	1.0%
electricity	unit cost	standard credit	380	3.1%
gas	standing charge	Not prepayment as assumed fixed tariff	850	8.9%
gas	standing charge	other	8440	88.5%
gas	standing charge	prepayment	60	0.6%
gas	standing charge	standard credit	190	2.0%

gas	unit cost	Not prepayment as assumed fixed tariff	1060	10.9%
gas	unit cost	other	8160	83.6%
gas	unit cost	prepayment	360	3.7%
gas	unit cost	standard credit	180	1.8%

The results show levels of prepayment electricity meters relatively stable over time at around 1%, with agreement on levels between unit cost and standing charge. This level is in agreement with the level identified from the cost-of-living crisis survey.

Levels of gas prepayment meters are more variable over time and across tariff components. According to gas unit costs, prepayment levels were around 4% in March 2022 and March 2023 but in contrast were only 0.6% in September 2022. Prepayment levels according to standing charges were also lower, with only 0.6% in March 2023. The cost-of-living crisis indicated gas prepayment levels of around 1%, so this suggests a potential issue with the identification of prepayment status based on gas unit costs.

As for standard credit payment status, the results indicate levels dropping over time for gas meters, with 4.9% observed in March 2022 (with agreement across unit cost and standing charge), dropping to 3.6-4.0% in September 2022, and then 2.0% in March 2023. A similar situation is observed for standard credit electricity meters, with levels of around 4.5% in March 2022, dropping over time to around 3% in March 2023. The cost-of-living crisis survey (conducted Jan-Feb 2023) indicated standard credit levels of around 4% for electricity and 3.4% for gas, suggesting a possible slight under-identification of standard credit in March 2023 through the imputation rules and EPG-matching processes.

This levels remaining levels of around 95% for the other payments consisting of ‘other’ and ‘not prepayment as assumed fixed tariff’. These are likely to correspond to the direct debit payment status category observed in the cost-of-living crisis survey responses.