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Comparing counts of electricity meters and addresses by postcode in England and Wales

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Abstract

This paper presents an initial investigation into aggregated electricity meters count data published by the *Department of Energy and Climate Change (DECC)* for 2013.

The objective of the investigation is to evaluate if counts of electricity meters can give insight about areas with complex household arrangements such as multi-occupancy properties or flats. On the assumption that any single address will most likely have one electricity meter, this analysis compares England and Wales (E&W) postcode data about the number of domestic electricity meters with the number of residential addresses and examines postcodes where these two data sources differ greatly. Understanding why there are differences between meters and addresses counts will help ONS to enhance the quality assessment of the AddressBase, ultimately resulting in a better assistance for activities that rely on addresses information such as Census field operations.

First a description of the research data is given, highlighting some of the issues that have been found while assessing its quality for the purpose of linking this data to the ONS AddressBase. Then electricity meters count data at postcode and output area level are combined with the information known about addresses and the information given from the Output Area classification created using Census variables. Some case studies are then presented to show the findings acquired during the analysis.

The research indicates that counts of electricity meters might provide some intelligence on postcode areas where there are complex housing arrangements such as high proportions of flats and second/holiday homes.

1. Introduction

An electricity meter, electric meter, or energy meter is a device that measures the amount of electric energy consumed by a residence, business, or an electrically powered device (e.g. meters that power street lighting or traffic lights rather than a property). Electricity data is divided between domestic and non-domestic categories according to the meter's profile type.

In E&W[1] it is normal for a single residential address to have one domestic electricity meter.

The analysis presented here looks at postcode level counts of domestic electricity meters for E&W and compares them with postcode level counts of residential addresses from AddressBase.

Postcodes where these counts are significantly different may identify areas with complex household arrangements such as multi-occupancy buildings, holiday homes, park homes and caravans. Differences may also be attributable to new or demolished homes that may not have been updated in either dataset.

[1] For more information see DECC Methodology and guidance note.

This information would be useful to a Census operation as areas with complex housing can be difficult for a Census to enumerate[2].

2. Data

2.1. Electricity meter data

DECC has recently published data on domestic electricity meters for all postcodes across Great Britain (England, Scotland, and Wales). The data relates to the year 2013 and contains, for each postcode, an estimate of the total yearly electricity consumption, number of meters, average and median consumption estimates.

This data has been pooled from individual meter information provided by the six major UK energy companies, Eon, Scottish Power, Scottish and Southern Energy, Npower, British Gas and EDF Energy. These so called 'Big 6' companies registered in early 2014 a collective coverage of 95% of all domestic meters. The data is available for 8 different 'profiles' of meter, with domestic consumption based on meters with profiles 1 and 2 (these are the standard domestic and economy 7 type tariffs respectively). Industrial and commercial consumption data are based on meters with profiles 3 to 8 and thus excluded from the analysis.

In addition it should be noted that profile 1 and 2 meters are reallocated by DECC to the industrial and commercial sector if annual consumption is greater than 100,000 kWh. Also re-allocated to the industrial and commercial sector are those consuming over 50,000 kWh with address information indicating non-domestic consumption (for example, if an address contains 'plc' or 'ltd').

As a consequence, cases such as small businesses may have been included in the domestic figures while some other high use meters belonging to residential households may have been excluded.

Table 1 presents an extract of the initial data. The data is provided at postcode district (indicated by the first 2 to 4 characters before space in the full postcode string) and for individual postcodes with 6 or more meters. The postcode district aggregates together those postcodes with less than 6 meters. This is done by DECC to protect individual household data and eliminate the risk of identification. For example Table 1 shows the first row, the postcode district AB10, contains an aggregate count of 257 meters. There is no indication of how many postcodes have been masked and grouped together. Individual postcodes that have more than 6 meters (AB10 1AU, AB10 1BA, AB10 1BB) are listed individually.

[2] See Abbott and Compton (2014)

Table 1: ***A snapshot of the initial data***

Postcode	Total consumption (kWh)	Number of Meters	Mean (kWh)	Median (kWh)
AB10	1,303,518	257	5,072	3,269
AB10 1AU	109,478	40	2,737	2,067
AB10 1BA	81,214	40	2,030	1,461
AB10 1BB	47,361	9	5,262	2,481

During the cleaning phase all postcode districts were removed as well as postcodes in Scotland so that the data was left with valid postcodes from E&W only.

From the original 1,156,791 records in the dataset, the final number of observations for this dataset resulted in 1,044,112 postcodes (90.3%). First five rows are presented in Table 2.

Table 2: ***First five rows of electricity meter data***

Postcode	Total consumption (kWh)	Number of Meters	Mean (kWh)	Median (kWh)
AL1 1AJ	150,789	52	2,900	2,583
AL1 1AR	68,275	22	3,103	2,719
AL1 1AS	37,551	13	2,889	2,731
AL1 1BH	314,336	52	6,045	6,577
AL1 1BX	100,361	17	5,904	5,500

2.2. Address data

Data about residential addresses against which the electricity data was compared was sourced by ONS from AddressBase. AddressBase is a product which combines address and location information from various different sources, including from Ordnance Survey, Royal Mail and others.

The data used for this analysis is a snapshot of AddressBase extracted in June 2015. Addresses in each postcode are classified into several categories according to their use (e.g. residential, commercial, communal establishment and so on). Information about the number of residential addresses in E&W were extracted from AddressBase and aggregated to postcode level, providing a count of the number of these addresses per postcode.

The dataset contains a total of 1,451,641 postcodes and the first five rows of the extract are illustrated in Table 3.

Table 3: ***First five rows of the extract from AddressBase***

Postcode	Residential addresses
AL1 1AG	6
AL1 1AJ	52
AL1 1AR	20
AL1 1AS	13
AL1 1BH	48

2.3. 2011 Area Classification for Output Areas

Area classifications group together geographic areas according to key demographic characteristics common to the population in that area. The ONS 2011 Area Classification for Output Areas (2011 OAC) is built for small geographic areas known as output areas and was created entirely from 2011 Census data.

The classification places each E&W output area, as defined following the 2011 Census, into a group with those other output areas that are most similar in terms of census variables. This enables similar areas to be classified according to their particular combination of characteristics and to gain more of an appreciation of the composition of the individual areas.

The 2011 OAC is a hierarchical classification, consisting of three tiers: Supergroups, Groups and Subgroups.

In this analysis the eight Supergroups are used.

2.4. Postcodes

A full postcode such as AL1 1AG is known as a "postcode unit" and designates an area with a number of addresses or a single major delivery point. Unit postcodes are the base unit of postal geography and fall into two types:

- **Large user postcodes:** allocated to single addresses receiving at least 500 mail items per day (e.g. business addresses).
- **Small user postcodes:** collections of (usually) adjacent addresses. A single small user postcode may contain up to 100 addresses, but 15 is a more typical number.

It should be noted that it is possible for large buildings with many separate delivery points (for example, a tower block) to have more than one unit postcode within the building.
The following analysis uses the postcode units as the base unit of spatial aggregation for the data.

3. Analysis

For E&W postcodes the electricity meter data was merged with the AddressBase snapshot. The merged dataset had a total of 1,041,672 observations.

There were 409,969 more postcodes in the AddressBase snapshot than in the electricity dataset.

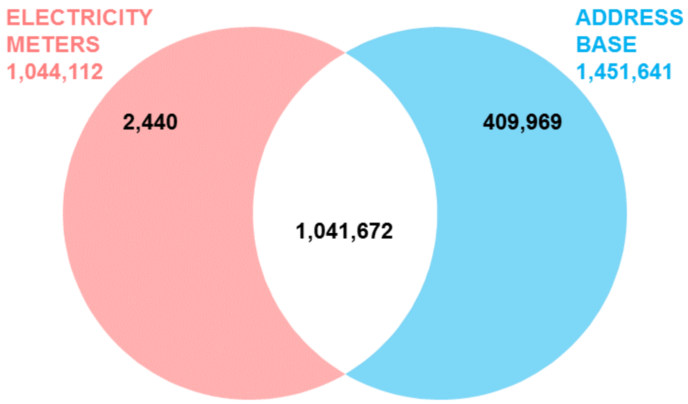
Some of the key reasons for this are:

- The difference in timing of the two datasets. Some postcodes that were created after 2013 were in the 2015 AddressBase snapshot but not in the 2013 electricity data. This accounted for 5,590 postcodes.
- Postcodes having less than 6 meters were suppressed and aggregated at postcode district level in the electricity data by DECC. This accounts for 379,513 postcodes.
- Different classifications of ‘residential’ between the two data sources. For example student accommodation such as *Graduate College Porter Lodge* in Lancaster or *Booth Hall* at Manchester Metropolitan University are classed as postcodes with high numbers of residential addresses in the AddressBase snapshot, yet classed as having non-domestic meters in the electricity data.

There were also 2,440 postcodes in the electricity data that could not be matched to a postcode in the AddressBase snapshot. Around 90% of these (2,183 postcodes) are no longer in use. Some of these postcodes ceased being operational as far back as the 1990s.

A Venn diagram in Figure 1 shows the intersection between the two datasets.

Figure 1: Venn diagram of the matching between the AddressBase snapshot data and the electricity data



3.1. Number of meters versus number of addresses

There are several reasons why the number of domestic meters from the electricity companies data may not exactly equal the number of residential addresses ONS have identified from AddressBase:

1. Misclassification between domestic and non-domestic meters as described above
2. An apartment building may have a meter for the building complex (used to power building-wide appliances) in addition to each individual apartment having its own meter.
3. Some meters power street lighting or traffic lights rather than a property.
4. Differences in timing between the two datasets as one is for 2013 and one 2015.
5. New/demolished buildings which may not have been updated in either data.

The relationship between the number of addresses and the number of meters shows a strong positive correlation of 0.94.

**Figure 2: Scatter plot of number of domestic electricity meters 2013 vs. number of residential addresses in 2015 for E&W.
The red line indicates where the number of addresses equals the number of meters.**

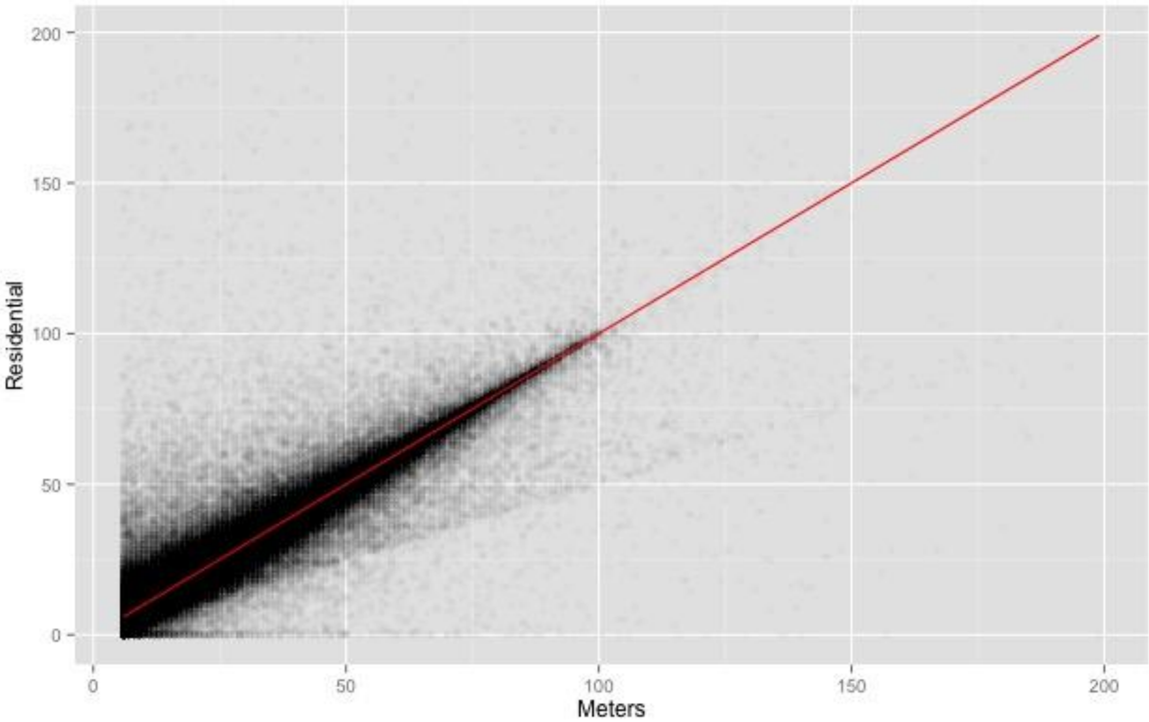


Figure 2 shows that the majority of points are clustered around the red line, where the number of meters is equal to the number of addresses. The plot area covers postcodes with up to 200 residential addresses or meters, although there are postcodes with higher numbers in the data. The starting point for the Meters axis (x axis) is 6, because postcodes with less than 6 meters are omitted by DECC.

The difference between the number of meters and the number of residential addresses was first calculated.

Figure 3: ***Distribution of the difference between number of meters and number of residential addresses for each postcode***

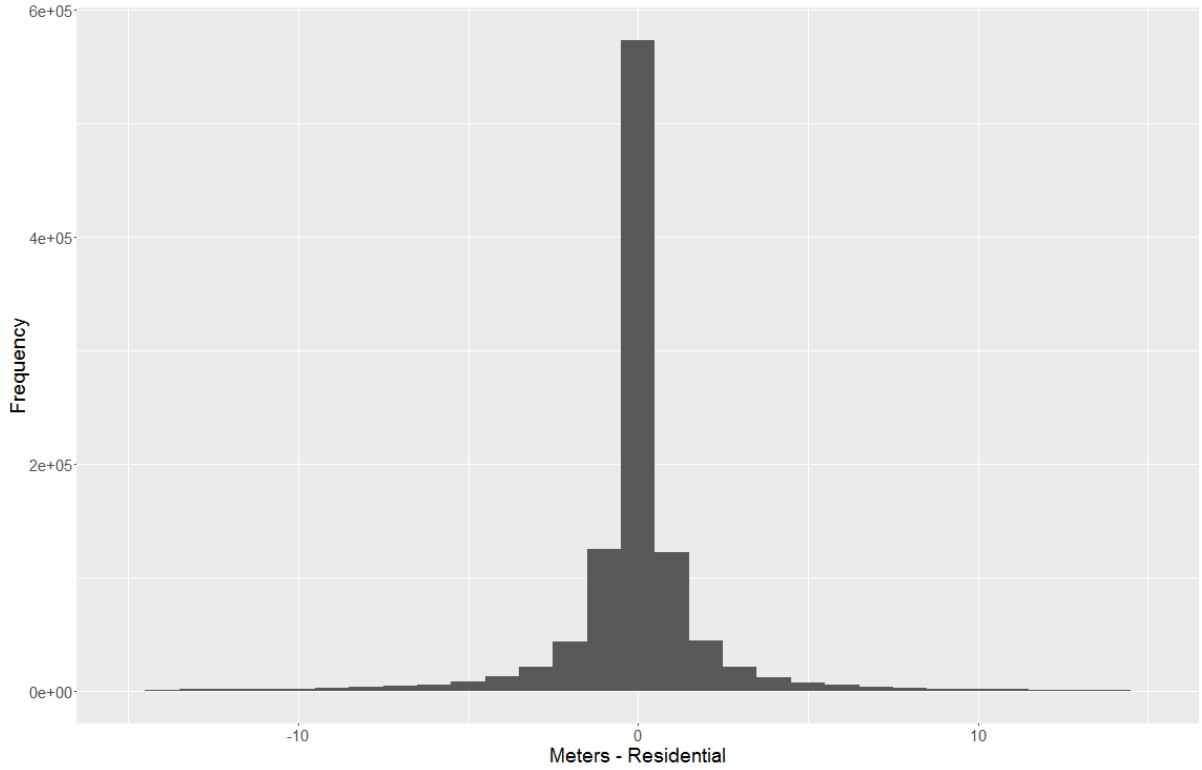


Figure 3 indicates that the distribution of the difference between the number of meters and the number of residential addresses appears to be normally distributed. This could be expected since the majority are postcodes which are generally small.

It is seen that 87% of postcodes have a difference between 2 and -2, and 98% of postcodes have a difference between 10 and -10. There are a small number of postcodes with very large differences between meter counts and addresses.

3.2. Outliers

By definition an outlier is an observation point that is distant from other observations. There is no rigid mathematical definition of what constitutes an outlier; determining whether or not an observation is an outlier is ultimately a subjective exercise.

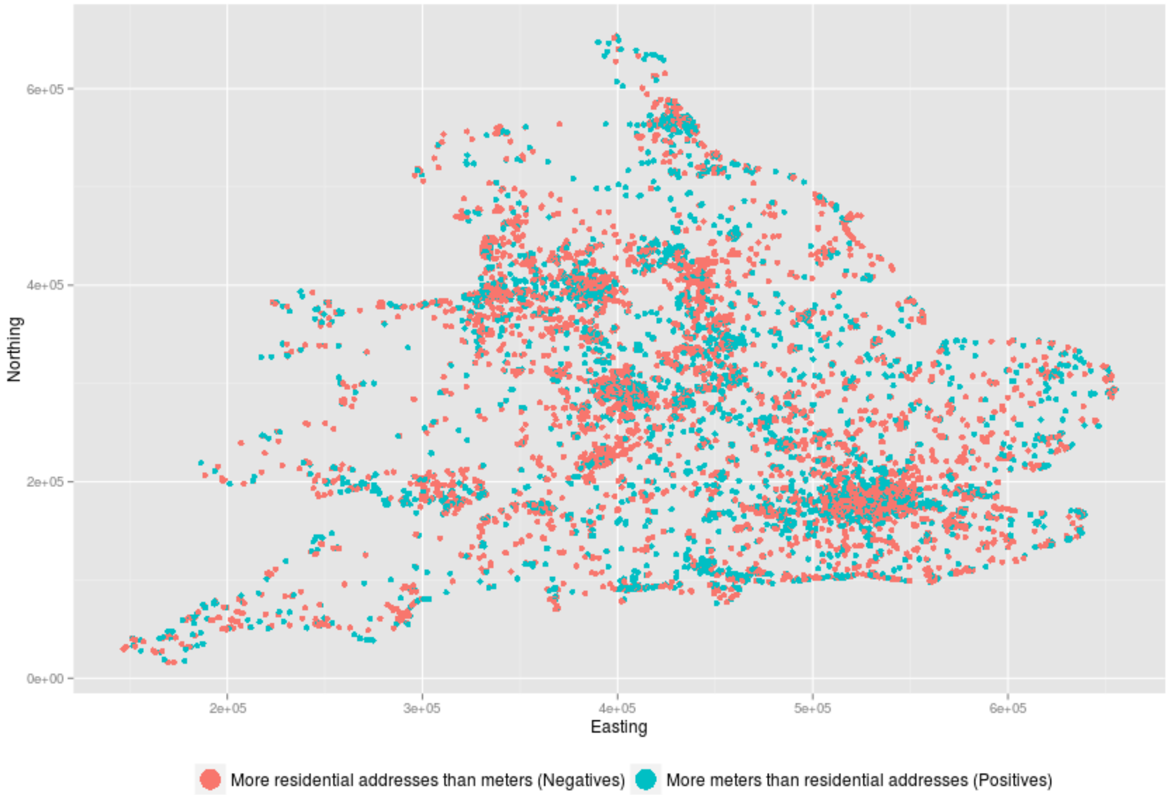
In this analysis, outliers are defined as those points greater than plus or minus 2.58 standard deviations of the mean. This effectively sets an outlier to be in the 1% of postcodes with the largest difference between meters and address counts.

The total number of outliers detected was 15,808.

It is possible to distinguish two distinct types of outliers:

- *Negatives*: the number of residential addresses is greater than the number of meters: 9,531 postcodes.
- *Positives*: the number of meters is greater than the number of residential addresses: 6,277 postcodes.

Figure 4: ***Geographical distribution of the outliers in E&W. Negative outliers are shown in red and Positives outliers in blue.***



The geographical distribution of both types of outlier, illustrated in Figure 4, resembles the geographical distribution of the residential population, with greater outlier density in highly densely populated areas such as London. However, it is possible to see a clear delimitation of the coastal areas, where we may expect to find a higher occurrence of holiday homes and caravan parks.

Table 4 illustrates some descriptive statistics for the two groups.

Table 4: ***Average values for negative outliers where the number of residential addresses is significantly greater than the number of meters and positive outliers where the*** **number of meters is significantly greater than the number of residential addresses.**

Summary statistics	Negatives Outliers	Positives Outliers
Average total consumption	105,011	218,229
Average number of meters	28	58
Average consumption per meter	3,979	3,783
Average number of residential addresses	57	31
Average deviation from 0	-29	27

3.3. Case studies

There are a high number of outliers in the areas of Hounslow, Isleworth, Twickenham, Brentford and Feltham and this is examined further in Figure 5.

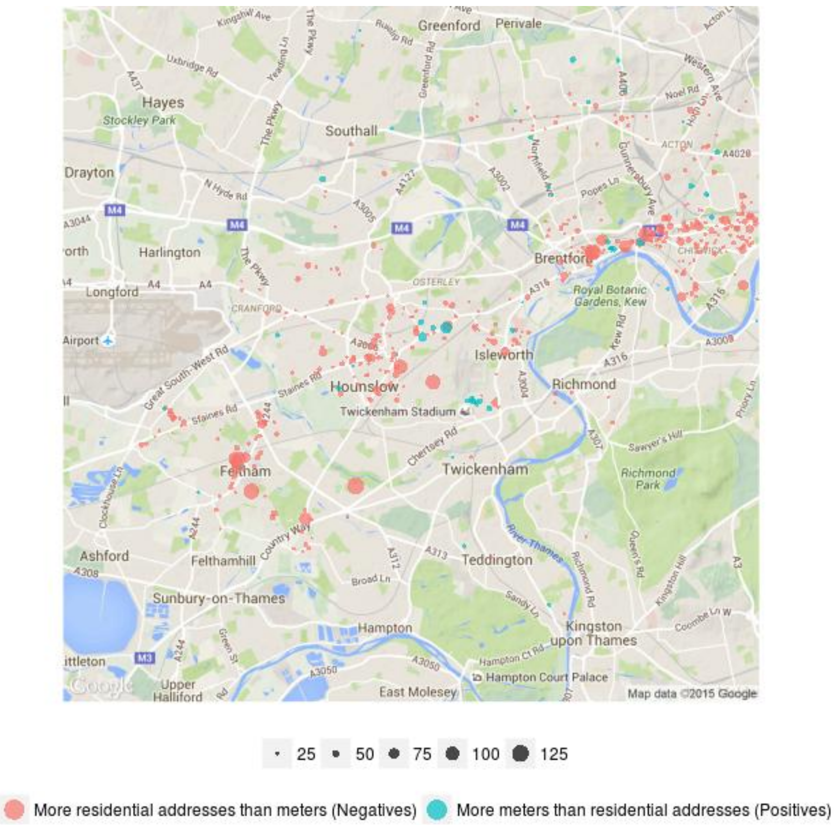


Figure 5: ***Geographical distribution of the outliers amongst the areas of Hounslow, Isleworth, Twickenham, Brentford and Feltham. Negatives and Positives outliers are shown in different colours. The size of the bubble refers to the magnitude of the difference from the mean.***

Figure 5 highlights the dominance of *Negatives* outliers, where the number of residential addresses is significantly greater than the number of meters.

The Local Authorities broadly covering this area are Ealing, Hounslow and Richmond upon Thames.

We can categorise each Output Area (OA) to be found within these three LAs into one of four different categories:

- **Positive –** if it contains at least one postcode positive outlier
- **Negative –** if it contains at least one postcode negative outlier
- **Mixed –** if it contains at least one positive and one negative outlier
- **Normal –** if it doesn't have any outliers

84% of the OAs in these LAs are categorised as Normal, whereas the percentages of OA that belong to Positive, Negative and Mixed are respectively 1.7%, 13.8% and 0.7%.

Using 2011 Census data, the housing composition for the OAs and categories represented are shown in Figure 6 and
Table 5.

This analysis reveals that output areas with outliers have much higher proportions of households living in flats than average.

Figure 6: ***Housing composition for Ealing, Hounslow and Richmond upon Thames. Output Areas by category: Positive, Negative, Mixed and Normal.***

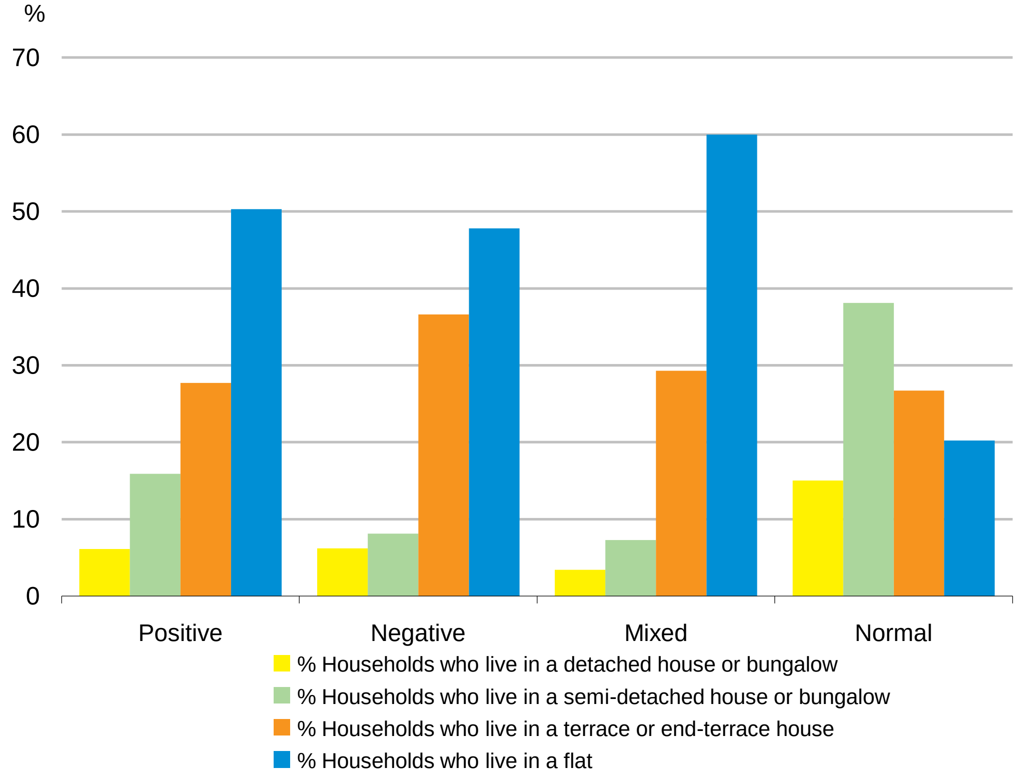
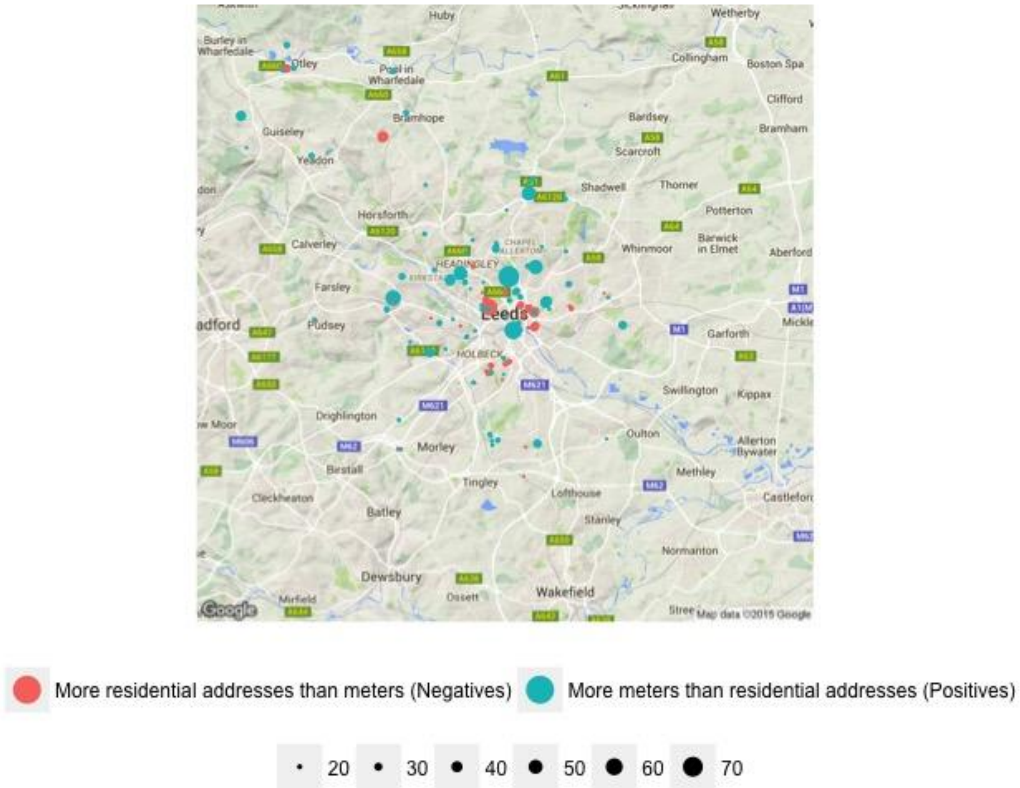


Table 5: ***2011 Census housing data for Ealing, Hounslow and Richmond upon Thames.***

	Housing Type composition			
Category	Households who live in a detached house or bungalow (%)	Households who live in a semi-detached house or bungalow (%)	Households who live in a terrace or end-terrace house (%)	Households who live in a flat (%)
Positive	2.6	9.6	19.2	68.5
Negative	4.7	19.4	18.2	57.3
Mixed	2.6	11.7	9.9	75.8
Normal	6.3	26.6	26.9	40.0

Another area of interest is Leeds as it is characterised by a high number of positive outliers (significantly higher number of meters than addresses). Figure 7 shows how the outliers are geographically distributed, distinguishing between *Negatives* and *Positives*.

Figure 7: ***Geographical distribution of the outliers amongst the areas of Leeds.***
Negatives and Positives outliers are shown in different colours.
The size of the bubble refers to the magnitude of the difference from the mean.



Using the same analysis as before, it is found that 96% of OAs in Leeds are categorised as Normal. There are 2.9% Positives, 0.8% Negatives and 0.4% Mixed.

The housing composition for the different categories of OA represented is shown in Figure 8.

Figure 8: ***Housing composition in Leeds. Output Areas by category: Positive, Negative, Mixed and Normal.***

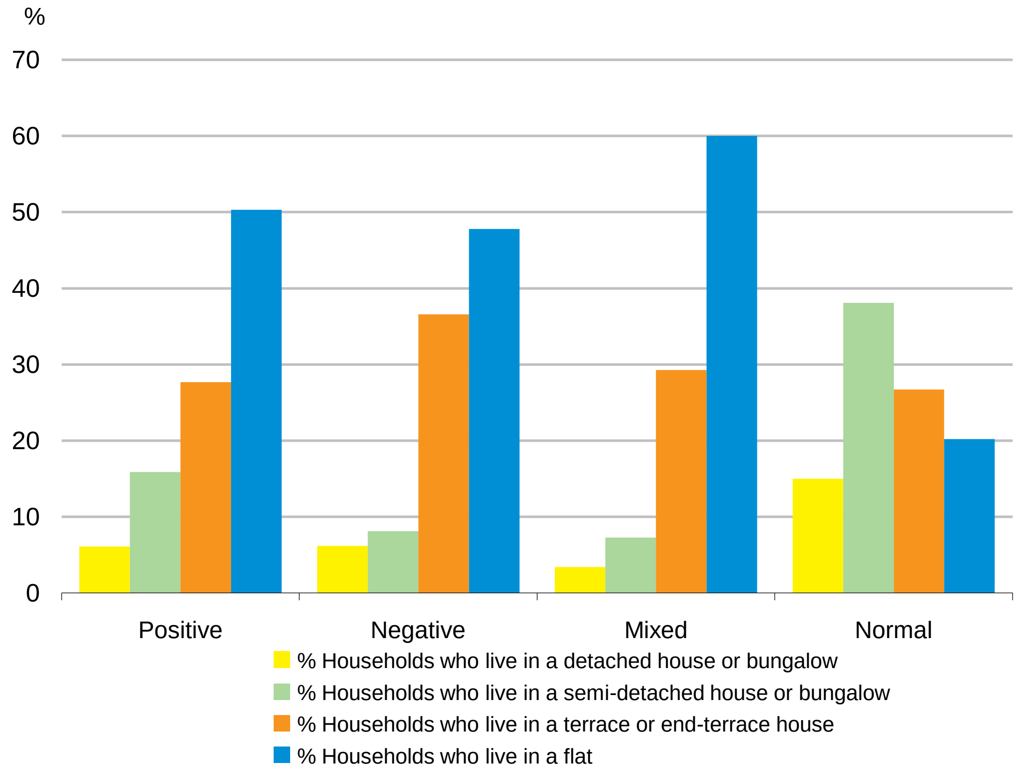


Table 6: ***2011 Census housing data for Leeds.***

	Housing Type composition			
Category	Households who live in a detached house or bungalow (%)	Households who live in a semi-detached house or bungalow (%)	Households who live in a terrace or end-terrace house (%)	Households who live in a flat (%)
Positive	6.1	15.9	27.7	50.3
Negative	6.2	8.1	36.6	47.8
Mixed	3.4	7.3	29.3	60.0
Normal	15.0	38.1	26.7	20.2

We can see that again the OAs categorised as containing outliers have high proportions of households living in flats.

3.4. 2011 Area Classification for Output Areas

The following section investigates the characteristics of OAs with outliers using the Census 2011 area classification.

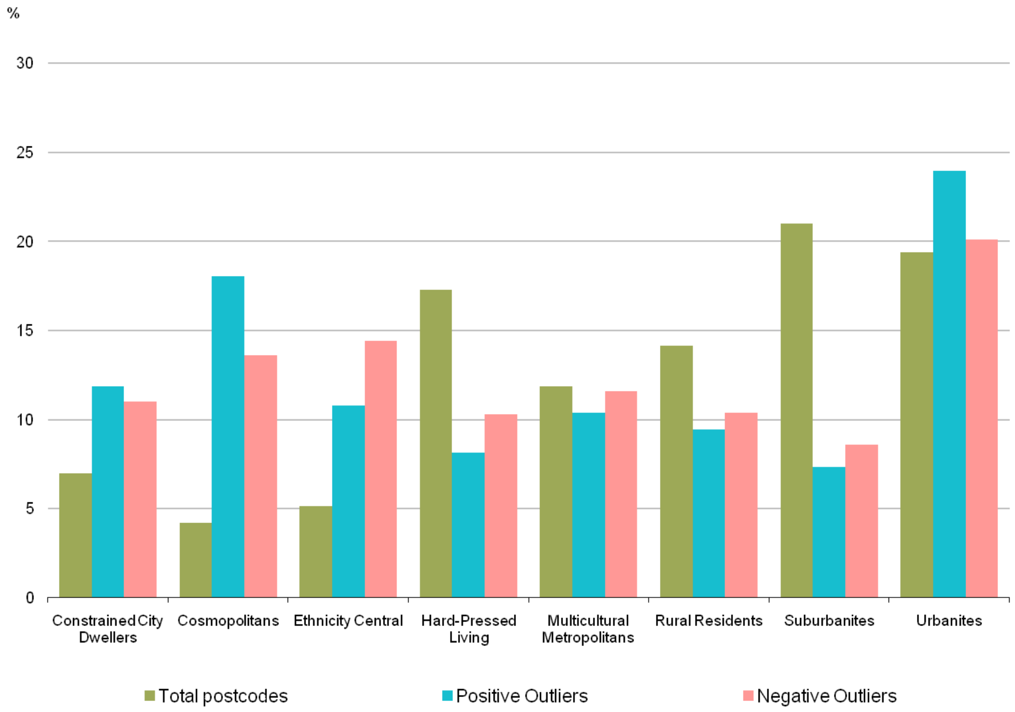
Across the whole country, each postcode was first assigned to an OA and then to one of the following eight Supergroup categories:

- Constrained City Dwellers
- Cosmopolitans
- Ethnicity Central
- Hard-Pressed Living
- Multicultural Metropolitans
- Rural Residents
- Suburbanites
- Urbanites

Figure 9 shows, for each Supergroup category:

- the percentage of all postcodes contained in the Supergroup
- the percentage of all positive outliers that lie in postcodes belonging to the Supergroup.
- the percentage of all negative outliers that lie in postcodes of the Supergroup

Figure 9: *Percentage of postcodes in each Supergroup categories for:*
- *Total postcode population*
- *Positive Outliers (more meters than residential addresses)*
- *Negative Outliers (more residential addresses than meters)*



A key message from Figure 9 is that postcodes assigned to the Supergroup categories of *Constrained City Dwellers*, *Cosmopolitans* and *Ethnicity Central* collectively represent around only 16% of all postcodes but have a much higher proportion of all negative and positive outliers (42% and 40% respectively). Conversely, the Supergroup categories of *Hard-Pressed Living* and *Suburbanites* represent approximately 38% of all postcodes but only 18% of all negative and 15% of positive outliers.

The area classification is created by grouping similar areas together based on a variety of data about each area from the Census, including data about housing types and tenure. The centroid for each Supergroup category represents the average of all areas within the Supergroup and can be used to understand the types of areas in the Supergroup. Here we analyse the different housing types and ownership arrangements for each Supergroup.

3.4.1. Housing Type

The *Housing Type* composition is described in four variables, listed as columns in Table 7. We analysed how much the mean for each Supergroup deviates from the national mean.

Table 7: ***Deviation from the E&W mean for 2011 Census Housing Type composition.***

Supergroup	Households who live in a detached house or bungalow (% deviation from E&W mean)	Households who live in a semi-detached house or bungalow (% deviation from E&W mean)	Households who live in a terrace or end-terrace house (% deviation from E&W mean)	Households who live in a flat (% deviation from E&W mean)
Constrained City Dwellers	-25	-9	7	35
Cosmopolitans	-35	-36	-9	42
Ethnicity Central	-34	-33	-9	44
Hard-Pressed Living	-10	11	15	-11
Multicultural Metropolitans	-13	2	16	11
Rural Residents	30	3	-8	-21
Suburbanites	23	8	-24	-31
Urbanites	5	2	8	12

From Table 7, it is seen that the three Supergroups that contain high number of outliers (Constrained City Dwellers, Cosmopolitans and Ethnicity Central) have much higher proportions of *'% Households who live in a flat'* compared with the national mean and with other Supergroups.

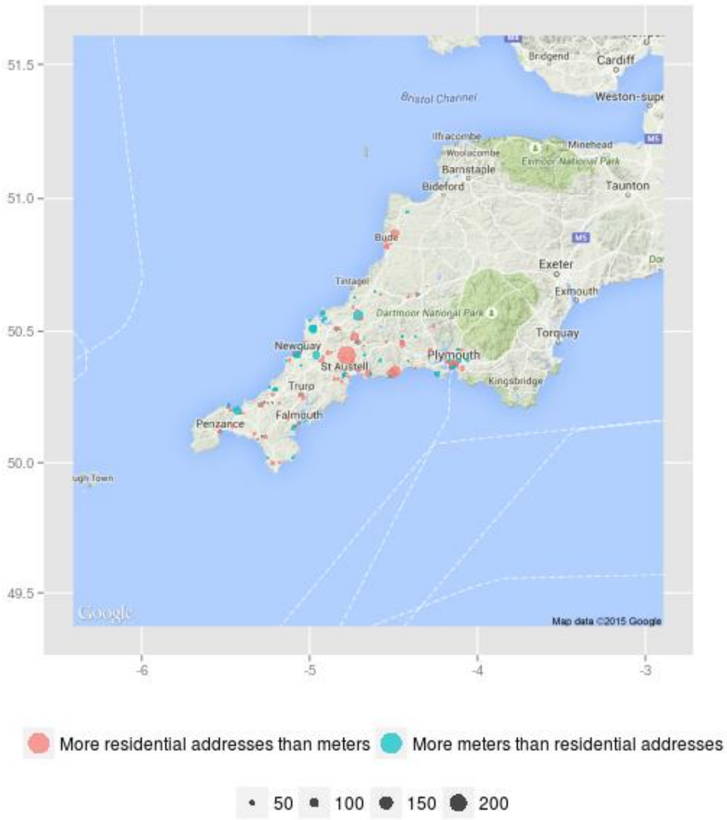
The Supergroups of Hard-Pressed Living, Rural Residents and Suburbanites all have much lower proportions of flats than the national mean.

3.5. Analysis of Cornwall region

Finally as Figure 4 has shown there appear to be many outliers at the coast. As a result Cornwall was examined further.

Figure 10 shows how the outliers are distributed in Cornwall local authority, distinguishing between negative and positive outliers. The size of the bubble refers to the magnitude of the outlier, so the bigger the size the bigger the difference between the number of meters and the number of residential addresses.

Figure 10: ***Geographical distribution of the outliers among the Cornwall region. Negative and positive outliers are shown in different colours. The size of the bubble refers to the magnitude of the absolute difference.***



By sampling some of the outliers in Cornwall it was observed that many of these postcodes are dominated by the presence of caravan parks, camping parks, holiday apartments and holiday homes.

Table 8: ***Sample from Cornwall region.***

Postcode	Description	Case	N. of residential addresses	N. of electricity meters

EX23 9QY	Self Catering Holiday Park	Negative	98	16
PL26 8QN	Static caravans and chalets	Positive	234	22
PL28 8PY	Holiday Park, caravan park	Negative	72	165
PL30 3PL	Holiday Park, caravan park	Positive	18	128
TR27 5AF	Seaside self-catering caravans	Positive	280	364

4. Conclusion

The target of this examination is to assess if counts of electricity meters can give insight about areas with complex household arrangements such as multi-occupancy properties or flats. On the assumption that any single address will most likely have one electricity meter, this analysis compares E&W postcode data about the number of domestic electricity meters with the number of addresses and examines postcodes where these two data sources differ greatly. This intelligence would be valuable for ONS to optimize activities that rely on addresses information such as Census field operations.

Using the postcode as match key, a total of 1,041,672 records in the 2013 electricity data were matched to postcodes showing the number of addresses from a snapshot of the 2015 AddressBase. Significantly, around 410,000 postcodes were missing from the electricity data provided to ONS by DECC, mainly because the data did not contain postcodes with six or less meters which could not be provided to ONS for data protection reasons.

For the majority of matched postcodes, the difference between the number of meters and number of residential addresses is around zero as expected. A correlation of 0.94 suggests a strong positive relationship between the number of meters and the number of addresses. The distribution of these differences is approximately normal.

Postcodes where the difference between the two counts is found to be significantly different are labelled as either a *negative outlier (*where the number of residential addresses is greater than the number of meters or a *positive outlier* (where the number of meters is greater than residential addresses). These two types of outlier contain 9,524 and 5,853 postcodes respectively.

An investigation into two areas having high numbers of either positive or negative outliers revealed that these areas have high proportions of households living in flats. The number of addresses may be greater than the number of meters if an apartment complex has only one meter for a group of flats. Alternatively, the number of meters may be greater than the number of flats where there is one meter per flat plus others for communal areas used for lighting, for example in student halls of residence.

Another analysis involved using the 2011 Census Output Area Classification to see whether the output areas in which the postcode outliers lie present some distinctive characteristics with respect to the *Housing Type* composition. It was found that outliers are more likely to be in the Supergroup categories *Constrained City Dwellers*, *Cosmopolitans* and *Ethnicity*

Central, areas which are more likely to contain flats. Correspondingly, outliers are found in far fewer proportions in areas where there is a lower prevalence of flats.

Finally, an investigation into the high level of outliers to be found in Cornwall revealed that these outliers are often postcodes dominated by the presence of caravan parks, camping parks, holiday apartments and holiday homes.

There are a number of considerations to be had regarding the comparability between the two data:

Timestamp	The electricity meter data is dated to the annual year 2013 and might include some sort of averaging of numbers. The data is also provided to DECC at a lag. This means that these counts will not be current, and changes due to new builds or demolitions not accounted for.
Classification of domestic and non-domestic meters	Electricity meters are categorised as being domestic or non-domestic according to the amount of electricity they use. It is possible that meters may be incorrectly categorised.

However, it is thought that AddressBase may not capture caravan parks well, sometimes showing only a few addresses for a large caravan site. In such circumstances, the number of meters is likely to be greater than the number of addresses. Alternatively, such properties may have non-domestic meters, leading to a greater number of addresses than meters.

The overall indication is that counts of electricity meters might provide some intelligence on the areas where there are more complex housing arrangements, most notably with flats and second/holiday homes.

It needs to be tested whether standard meter count data might improve census or survey fieldwork. This can be achieved by a closer look at postcodes with anomalies, for example by looking at all addresses in the postcode on AddressBase. Another piece of work would be to look at census test outcomes and interview observations for some affected postcodes, comparing counts of electricity meters, at postcode level, with the addresses to be used within tests for the 2021 Census. These tests will run in certain areas in 2016 and 2017. Postcodes with large differences in counts might then be investigated using feedback from the fieldworkers to help identify any value added from using meter counts prior to sending out forms or from follow-up. An additional option would be supplement the above by directly including some of these postcodes in the 2016 address check in Telford & Wrekin.

Finally, it is also acknowledged that the government has a policy to roll out smart meters to over 26 million households across Wales, Scotland and England by the end of 2020. Counts of standard meters will fall whilst active electricity smart meters will rise over this time; potentially leading to more accurate and timely counts overall.