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Lights, appliances, and smart technologies

Final report

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Executive Summary

This report presents the findings of the EFUS lights, appliances and smart technologies analysis. The reported findings are based on EFUS interview data, in addition to electricity consumption data collected between 1st May 2018 and 30th April 2019. The main findings are as follows:

Lighting

- Low energy LED and fluorescent strip were the prevalent lightbulb types used in the kitchen, with 35% of householders having at least one LED lightbulb in their kitchen, and 33% having at least one fluorescent strip lightbulb.
- Low energy CFL were the prevalent lightbulb type in the other main rooms; living room, main bedroom and hallway, with 44% of households reporting at least one CFL lightbulb in their living room, 45% in their main bedroom and 44% in their hallway.
- Timeseries analysis suggests there has been a decrease in ownership of tungsten filament and fluorescent strip lightbulbs since the 1998 EFUS, with the decrease in ownership of these types of lightbulb also significant when comparing between the 2011 and 2017 EFUS.
- Of the four main rooms in the house, the living room had the highest median number of lighting hours in both summer; two hours compared with one in the kitchen, bedroom and hallway, and winter; six hours compared with three in the kitchen and one in the bedroom and hallway.
- Analysis between weekday and weekend day lighting use suggests that the majority of households did not change their lighting habits, and where there was a change, more lighting was used at the weekend. This was true of both summer and winter lighting use.

Appliances

- Considering laundry appliance ownership, 97% of households owned a washing machine while only 58% owned a tumble dryer[1].
- The majority of households owned a fridge[2] and owned a freezer[3]; 99% and 93% respectively.
- Ownership of dishwashers has increased steadily between the three EFUS; 21% in 1998, 38% in 2011 and 44% in 2017.

[1] Both washing machine and tumble dryer ownership includes combined washer dryers.
[2] This includes fridge-freezer, separate fridge, separate fridge with ice box and American style fridge-freezer.
[3] This includes fridge-freezer, separate freezer and American style fridge-freezer.

- Ownership of ovens, hobs and microwaves was high among households; 96%, 92% and 90% respectively, whereas reported ownership of grills was much lower; 65%, and only 3% of households reported owning a range style cooker.
- The most common cooking appliance combination was electric oven with electric hob (37%) followed by electric oven and gas hob (33%)
- The majority (96%) of households owned a TV (or digital TV box) and a mobile phone (94%) while ownership of other electrical entertainment appliances was lower. Composition of a household affected ownership of electrical entertainment devices, with households with at least one child present more likely to own games consoles, laptops, mobile phones, tablets and internet connected speakers compared with those without.
- Considering the predominant fuel used by different cooking appliances, electricity was the most dominant fuel used in oven and grills; 73% and 48% respectively, while gas was the dominant fuel used in hobs; 54%. The use of electricity as the dominant cooking fuel has increased between the three EFUS; 1998, 2011 and 2017.

Smart Technology

- Ownership of smart lighting devices was low across households with only 3% of households owning at least one smart lighting device when asked during Interview 1. At interview 3, ownership of at least one smart lighting device had increased to 7% of households.
- The most commonly owned smart appliances were internet connected digital TV boxes (81%) and internet connected smart TVs (55%).
- Ownership of smart meters, either electricity or gas, was reported at 27% at Interview 1, and 36% at Interview 3. Of those owning a smart meter, 78% reported owning an energy display.
- Ownership of smart heating controls was low, with 8% of households reporting ownership of one at Interview 2, 9% at Interview 3.
- Only 4% of households reported owning PV, of these, 54% reported changing the time they ran their appliance to coincide with the time PV panels were generating electricity.

Electricity Consumption

- The median electricity consumption profile across all households for the whole detailed consumption monitoring period showed an increase in consumption over the morning, a plateau across the late morning and early afternoon before increasing again to reach a peak in consumption at 17:00. Consumption then decreased steadily throughout the evening.

- The number of occupants and the floor area of the dwelling had a direct impact on the electricity consumption with higher median consumption observed throughout the day as the number of occupants in the household or the floor area of the dwelling increased.
- The mean and median average daily consumption was higher in households that used electricity as their main heating fuel; 13.7 and 11.7 kWh respectively for electrically heated dwellings compared with 9.5 and 8.2 kWh for non-electrically heated dwellings. There was a large difference in the winter daily profiles of households by main heating fuel, while other seasons had similar levels of consumption.
- Electricity consumption data was also collected as part of the EFUS 2011. The estimated median annual consumption calculated from the 2017 data was lower (3,000 kWh) than that reported in 2011 (3,900 kWh). Mean electricity consumption was higher throughout the day in 2011 compared with 2017, although the patterns of use throughout the day were similar, particularly across different months of the year.

1. Introduction

There is an ongoing requirement to keep our knowledge and understanding of domestic energy use up to date. This is essential to ensure that policies, and policy interventions, are directed in the most efficient and effective manner; that legislation and standards are based on principles and assumptions that reflect how people are actually using energy in their homes; and that models and statistics which provide the underpinning evidence base in this area are as accurate as possible. Of particular relevance at the moment are policies relating to fuel poverty, decarbonisation of heat, smart metering and minimising household energy bills.

The data presented here is from the 2017 Energy Follow-Up Survey (EFUS). This was a follow-up survey of a sample of respondents from the English Housing Survey (2014-2017) and provided more detailed information on use of heating, hot water and appliances. Similar Energy Follow-Up Surveys were carried out in 1998 and 2011.

The Department for Business, Energy and Industrial Strategy (BEIS) has several overarching aims which need to be addressed by this new EFUS. These are:

1. To determine current domestic energy consumption and heating patterns in England and to investigate how they change over time through timeseries comparisons.
2. To understand how and why there are variations in energy consumption between similar dwellings, and similarities in energy consumption between different dwellings.
3. To understand how households in fuel poverty use energy and how their energy consumption patterns and behaviours compare with non-fuel poor households.

The questions addressed in this report on ‘Lights, Appliances and Smart Technologies’ are:

- What are the prevalent types of lightbulb in households and how has this changed over time?

- Does lighting use differ between weekdays and weekend days?
- What appliances do households have and has this changed over time?
- What is the current prevalence of smart technologies (such as smart lighting, smart appliances and smart meters) and other demand-side activities (such as PV)?
- How does electricity consumption change over a typical day and week? What effect do different days (weekday vs weekend) and household characteristics have on typical electricity consumption?

2. Methodology

Full details of the data collection and analysis methods used are set out in a separate methodology report, however, an outline is given below of the analysis, the interview surveys upon which this report is based and the detailed electricity consumption data.

2.1 Surveys

The first of the householder surveys was undertaken in the autumn of 2017 and is referred to as Interview 1. A pilot survey of 94 households was carried out between May and June 2017, followed by the main survey of 1,867 households. This survey was conducted via a face-to-face interview conducted in the householders' home between August and October 2017. In order to boost the sample, an online version of the same survey was completed by a further 671 households between October and December, giving a total sample of 2,632.

The Interview 1 survey examined a number of areas including;

- Summer thermal comfort
- Cooling behaviours
- Hot water use
- Appliance use
- Lighting
- Energy tariffs and method of payment
- Dwelling improvements
- Changes to the household

The second of the householder surveys, a follow-up survey to Interview 1, was conducted between January and March 2018 and is referred to as Interview 2. To minimise disruption to the householders the survey was conducted via a telephone interview and 1,060 households completed the telephone survey. As with Interview 1, in order to boost the sample an online version of the Interview 2 survey was completed by a further 280 households, giving a total

sample of 1,340. Therefore almost 51% of the Interview 1 households also completed the Interview 2 survey.

The Interview 2 survey examined;

- Use of main, alternative and supplementary heating systems
- Winter thermal comfort
- Winter ventilation behaviours
- Damp and mould
- Winter appliance and hot water use
- Lighting
- Trade-offs made by households unable to afford to heat their homes
- Occupancy patterns

The third of the householder surveys, another follow-up survey to Interview 1, was conducted between February and March 2019 and is referred to as Interview 3. The survey was conducted via a telephone interview and online survey; 447 households completed the telephone survey and a further 739 households responded online, giving a total sample of 1,186. Some 80% of the Interview 3 surveys had an Interview 1 and Interview 2 survey (944 households), while the remaining 242 households had an Interview 1 survey only. The interview 3 survey collected information on:

- Use of main heating systems including the heating season
- Proportion of the house heated
- Occupancy patterns
- Smart technologies
- Method of payment and tariffs
- Changes to property and household

The results presented in this report are based on the householder responses to questions from all three interview surveys. The respective survey is referenced within the text.

2.2 Detailed electricity consumption data

As part of interview 1, households could opt to have their gas and/or electricity consumption monitored using devices that attach to the gas/electricity supply near the meter and monitor flow every half an hour (in the case of gas) and every two seconds (for electricity). This report will focus on the results from monitoring the electricity consumption. Gas consumption is analysed in the ‘Household Energy Consumption and Affordability’ report.

Detailed electricity consumption data was collected from January 2018 to May 2019, with monitors installed in households between January 2018 and October 2018. The large time

frame over which installations occurred means there are different amounts of consumption data recorded for each household. In order to minimise large variations in the amount of data being analysed for each household a detailed consumption monitoring period was defined, chosen to run from 1st May 2018 to 30th April 2019. This period maximises the data available for analysis over the EFUS heating season, particularly relevant for the gas consumption data, while also covering a full year of data.

Valid electricity consumption data was collected in 436 households across the detailed consumption monitoring period.

Electricity consumption data was collected every two seconds for each monitored household and these readings were summarised and averaged for analysis. Values calculated include:

- Daily averages for each household, calculated by summing the electricity consumption each day to a daily total, then averaging these daily totals across a time period of interest and;
- Hourly averages for each hour in the day for each household, calculated by averaging the two second values into an hourly value, then averaging across all days in which data is recorded for that hour over a time period of interest.

Time periods of interest include the detailed consumption monitoring period (1st May 2018 to 30th April 2019), seasons and months of the year.

2.3 Weighting

The weighting factors for all three interview surveys were derived using a RIM weighting method and logistic regression, based on population targets so that each household in the EFUS dataset represent the number of households in England in 2017 (23.95 million) and 2018 (24.17 million). Further details are provided in the separate methodology report.

2.4 Analysis

Statistical analysis was used to measure the significance of the findings presented in this report. All statistical analysis was conducted on weighted data, and a design effect factor was used to account for the complex survey design. Further detail on the analysis is provided in the full methodology report.

The key dependent variables used in each chapter have been analysed by the defined set of EFUS social demographic and dwelling characteristic variables (listed below). As a rule, only statistically significant results at the 99% level (where $p < 0.01$) have been included in the text, although there are some instances when results that are significant at the 95% level ($p < 0.05$) are reported.

Household characteristics: tenure, household composition, household size, presence of pensioner, presence of child, age of the HRP (household reference person), employment

status of household, household income, daytime occupancy, anyone in the household designated long-term sick or disabled, under-occupying status and fuel poverty status.

Dwelling characteristics: dwelling type, house or flat, dwelling age, floor area, region, rurality, presence of central heating, main fuel used, wall type, insulated walls, loft insulation thickness, double glazing extent, number of insulation measures and Energy Performance Certificate (EPC) rating band.

Further details on these characteristics are located in the Glossary.

The following tests were used:

- The Chi-Squared (X2) test was used when comparing two categorical variables to determine if they are independent. Alongside this the Z-test for proportions was used to determine where the differences occur, with a Bonferroni correction. Cramer's V test was used to analyse the effect size.
- McNemar's test was used when comparing two categorical variables, for a repeated measures design.
- The Kruskal-Wallis test was used for non-parametric analysis of continuous or discrete data, to determine the impact of categorical variables. The Mann-Whitney U test was used to determine where the differences occur, and the effect size was approximated based on the r statistic.
- Paired T-tests were used when comparing two continuous variables, for a repeated measure. The Wilcoxon-signed rank test was used for non-parametric paired analysis.

All frequencies and percentages reported in the text have been rounded, with percentages rounded to the nearest percent.

In this report, where householders responded 'don't know' to a question, and if the proportion of 'don't know' responses was less than 5% of the weighted sample then these were set to missing and excluded from the analysis.

3. Lighting

This section of the report outlines householders' answers to the EFUS 2017 interview survey about the types of lightbulbs they own, including tungsten filament lightbulbs, low energy lightbulbs (LED; Light Emitting Diode and CFL; Compact Fluorescent Lightbulb), halogen lightbulbs and fluorescent strip lights. Lighting use on a typical weekday and weekend day in summer and winter was also examined. Responses to survey questions are compared across socio-economic variables and with previous EFUS results where appropriate.

3.1 Types of Lighting

During Interview 1, all householders were asked about the presence and number of different types of lightbulbs in each of the main rooms of the dwelling: kitchen, living room, main bedroom and hallway/landing[4]. On average, the living room and kitchen both had four lightbulbs (living room LQ: 2; UQ: 7; kitchen LQ: 1; UQ: 8), whereas the main bedroom and hallway had two lightbulbs (both rooms LQ: 1; UQ: 3).

Figure 3.1 shows the percentage of households that reported the presence of at least one of that type of lightbulb, for each of the four rooms. In the kitchen, the main lightbulb types used were low energy LED (35%), fluorescent strip (33%) and halogen bulbs (30%). The main lightbulb type used in the living room, main bedroom and hallway/landing was low energy CFL (44%, 45% and 44% respectively).

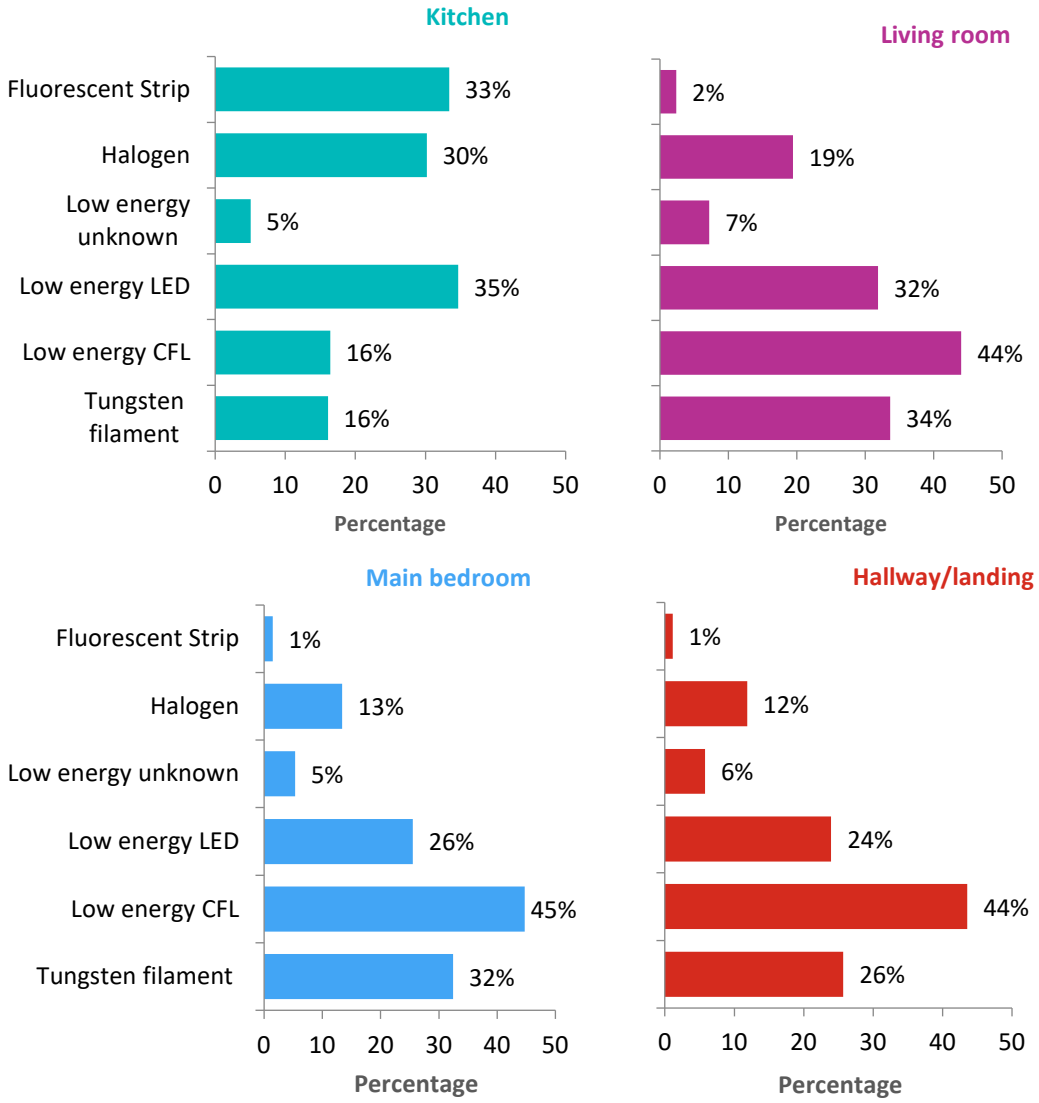
Analysis by socio-economic characteristics suggests the following groups were more likely to own each of the most prevalent lightbulb types:

Low Energy LED

- Owner occupiers (62%) compared with all other tenures (25% to 44%), and private renters (44%) compared with social renters (25% local authority, 29% housing association)
- Households comprised of couples (ranging from 59% to 61% depending on type) compared with households comprised of a lone parent with dependent children (36%) and one person aged 60 or over (40%)
- Households in the fifth income quintile (65%) compared with households in the first (41%), second (47%) and third (54%) income quintiles. In addition, households in the third and fourth quintile (54% for each category) compared with households in the first quintile
- Households with two or four occupants (56% and 63% respectively) compared with one-person households (43%)
- Households with at least one person in employment (56%) compared with no-one in employment (45%)
- Households under-occupying their home (59%) compared with households not under-occupying (49%)
- Non-fuel poor households (54%) compared with those in fuel poverty (43%)

[4] Annex tables containing the underlying data for this section can be found in Tables_3_1.xls.

Figure 3.1: Number of households with at least one type of lightbulb in each of the main rooms



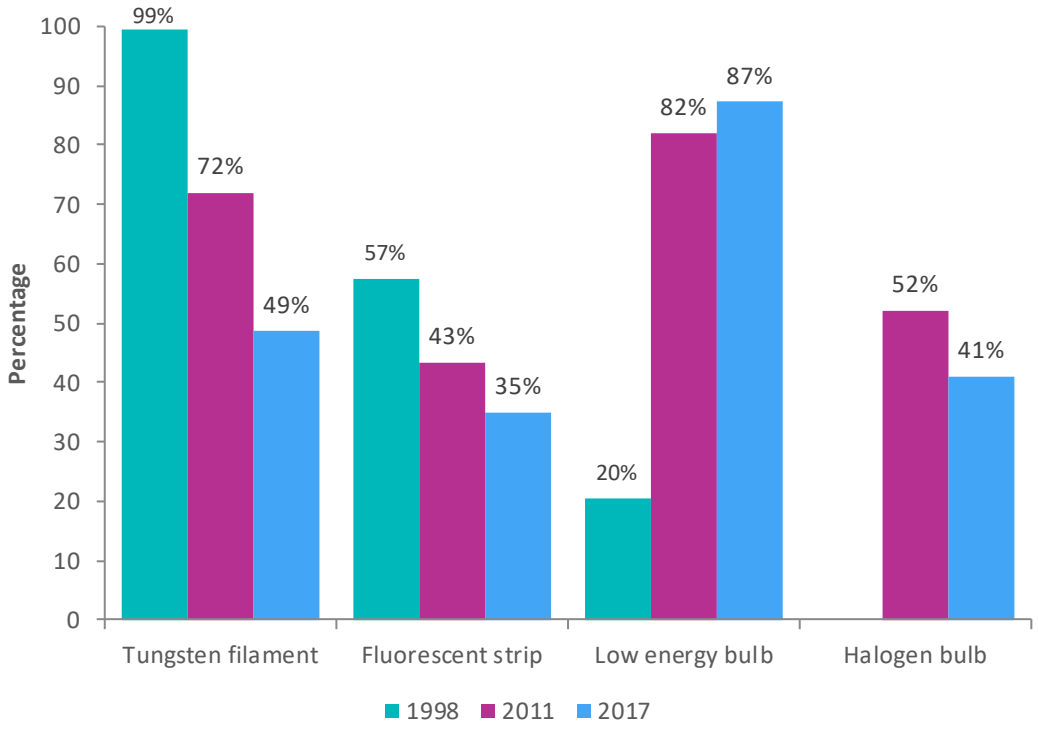
Base: all households with a lit living room, main bedroom, kitchen or hallway/landing (n=2,570-2,571 kitchen, n=2,603 living room, n=2,588 main bedroom, n=2,582 hallway/landing), Interview 1.

Tungsten Filament

- Households with an HRP aged 65-74 or 75 years or over (54% and 56% respectively) compared with households with an HRP aged 35-44 (40%)
- Households with at least one member over the state pension age (56%) compared with those without (45%)
- Households with no-one in employment (53%) compared with those with at least one person in employment (46%)
- In the living room, kitchen and main bedroom, timeseries analysis shows that there has been an increase in the use of low energy bulbs and a decrease in the use of tungsten

filament and fluorescent strip bulbs since 1998. Between 2011 and 2017, there has been a decrease in halogen bulbs (52% to 41%) (Figure 3.2).

Figure 3.2: Household ownership of different lightbulb types in their home, 1998, 2011 and 2017[5]



Base: all households (n=2,619 EFUS 1998, n=2,459-2,557 EFUS 2011, n=2,590-2,606 EFUS 2017) EFUS 1998, EFUS 2011 and Interview 1.

3.2 Lighting Use

Householders were asked to report how long the lights were on during a typical summer, and a typical winter, weekday and weekend day in the living room, kitchen, main bedroom and hallway/landing[6]. Table 3.1 shows the median hours per day that each main room was lit during summer and winter, for both weekdays and weekends.

3.2.1 Summer Lighting Use

On a typical weekday during the summer, the living room, kitchen, main bedroom and hallway/landing were most commonly lit for up to three hours (83%, 87%, 97% and 88% respectively). The most common lighting hours were unchanged on weekend days; up to three hours in the living room, kitchen, main bedroom, and hallway/landing (77%, 82%, 90% and 82% respectively).

[5] Respondents were not asked about Halogen bulbs in 1998.
[6] Annex tables containing the underlying data for this section can be found in Tables_3_2.xls.

The majority of households reported using lights for the same amount of time on summer weekdays and weekend days (living room: 89%, kitchen: 91%, main bedroom: 95%, hallway/landing: 95%). When households did report a difference, they used lights for longer at the weekend in the living room (weekend 7%; weekday 3%) and kitchen (weekend 6%; weekday 3%).

3.2.2 Winter lighting use

On a typical weekday during the winter, the living room was most commonly lit between three and six hours (57%), whereas, the kitchen, main bedroom and hallway/landing were most commonly lit for up to three hours (56%, 93% and 68% respectively). The most common lighting hours were unchanged on weekend days; between three and six hours in the living room (56%) and up to three hours in the kitchen, main bedroom, and hallway/landing (53%, 91% and 67% respectively).

During the winter, it was found that the majority of households reported using their lights for the same amount of time on weekdays and weekend days (living room: 72%, kitchen: 72%, main bedroom: 82%, hallway: 83%). The households that did report a difference in lighting use, used more lighting on the weekend compared with weekdays, in all reported rooms. In the living room, 23% of households reported an increase in lighting hours on the weekend, while 6% reported a decrease.

Table 3.1: Median hours of lighting in the main rooms of the home on weekdays and weekends during summer and winter

		Summer			Winter		
		Sample size	Median (hrs:mins)	IQR for median (LQ, UQ)	*Sample size*	Median (hrs:mins)	IQR for median (LQ, UQ)
Living room							
	Weekday	*2,525*	2.00	(1.00, 3.00)	*1,309*	6.00	(4.00, 7.00)
	Weekend	*2,492*	2.00	(1.00, 3.00)	*1,306*	6.00	(5.00, 7.00)
Kitchen							
	Weekday	*2,517*	1.00	(1.00, 2.00)	*1,290*	3.00	(2.00, 5.00)
	Weekend	*2,486*	1.00	(1.00, 2.00)	*1,287*	3.00	(2.00, 6.00)
Bedroom							
	Weekday	*2,500*	1.00	(0.5, 1.00)	*1,293*	1.00	(0.50, 2.00)
	Weekend	*2,421*	1.00	(0.5, 1.00)	*1,287*	1.00	(0.50, 2.00)
Hallway/landing							
	Weekday	*2,494*	1.00	(0.25, 2.00)	*1,266*	1.00	(0.50, 5.00)
	Weekend	*2,427*	1.00	(0.25, 2.00)	*1,264*	1.00	(0.50, 5.00)

Base: all households, Interview 1 and Interview 2.

4. Appliances

Householders were asked to report ownership and use of a range of electrical appliances including laundry appliances, dishwashers, cold appliances, cooking appliances, televisions and entertainment appliances. Where an appliance was not working or not used, householders were asked to exclude it from their answers. Ownership is compared across household types,

socio-economic variables and with EFUS 2011 and EFUS 1998 results where appropriate comparisons could be made.

4.1 Domestic Appliances Ownership

As part of Interview 1, all households were asked to specify what domestic appliances, if any, they used in their homes. Appliances have been grouped into the following categories for analysis, including analysis by socio-economic characteristics; laundry appliances, cold appliances, dishwashers, entertainment devices, cooking appliances, energy intensive electrical appliances and electrical cooling equipment[7]. Table 4.1 shows the number and percentage of householders that owned at least one of each of the domestic appliances asked about[8], along with reported ownership from the 1998 and 2011 EFUS. Ownership is only included for the previous years where the comparison is possible and appropriate. Appendix A provides a more detailed breakdown of ownership reported in the 2017 EFUS, along with additional comparisons with 1998 and 2011 ownership.

4.1.1 Laundry Appliances

Households were classified as owning a washing machine if they had at least one of the following: combined washing machine and tumble dryer, or a separate washing machine. Households were classified as having a tumble dryer if they owned at least one of: combined washing machine and tumble dryer, or a separate tumble dryer. With the categories collapsed into ownership of at least one type of washing machine or tumble dryer, 97% of households owned at least one washing machine while 58% owned at least one tumble dryer.

Analysis by socio-economic characteristics suggests that the following groups were more likely to own a washing machine or tumble dryer than other categories in their group:

Households with between two and four occupants (99% for each category) were more likely to own a washing machine compared with one-person households (92%), and households with two or more occupants (61% to 71% depending on size) were more likely to own a tumble dryer compared with one person households (43%)

- Owner occupiers (99%) were more likely to own a washing machine compared with private renters, local authority and housing association households (96%, 92% and 93% respectively). They were also more likely to own a tumble dryer (63%) compared with private renters, local authority and housing association households (49%, 48% and 54% respectively)

[7] Annex tables containing the underlying data for this section can be found in Tables_4_1.xls.
[8] Energy intensive electrical appliances have been reported on separately in Section 4.1.7.

Table 4.1: Summary of ownership of a least one of each domestic appliance, 1998, 2011 and 2017

	1998		2011		2017	
	Sample size	Percent (%)	*Sample size*	Percent (%)	*Sample size*	Percent (%)
Appliance:						
Washing machine	*2,057*	77.4	*2,202*	83.5	*2,274*	84.4
Tumble dryer	*913*	35.5	*1,227*	46.7	*1,281*	45.8
Combined washing machine and tumble dryer	*309*	14.6	*325*	13.6	*282*	13.2
Cold appliance:						
Fridge-freezer with large freezer	-	-	-	-	*1,763*	65.8
Separate fridges: without small ice-box freezer	-	-	*711*	28.1	*564*	22.8
Separate fridges: with small ice-box freezer	-	-	*485*	18.8	*456*	18.1
Separate freezer	*1,106*	47.3	*1,203*	46.1	*1,017*	38.2
American style fridge-freezer	-	-	-	-	*188*	7.4
Dishwasher	*411*	21.4	*929*	38.5	*988*	44.3
Cooking appliance:						
Oven	*2,432*	94.0	*2,397*	91.7	*2,525*	95.8
Hob	*2,442*	94.2	*2,408*	92.0	*2,372*	91.5
Grill	-	-	*1,756*	67.1	*1,708*	64.8
Aga/Rayburn style range cooker	*51*	1.6	*95*	4.0	*75*	3.1
Microwave	*1,902*	73.9	*2,088*	79.8	*2,381*	89.7
Entertainment Devices:						
TV	*2,580*	98.8	*2,570*	97.9	*2,542*	96.1
Digital TV boxes	-	- -	-	-	*1,892*	71.7
Games consoles	-	- -	-	-	*1,021*	36.3
Laptops	-	- -	-	-	*1,810*	71.8
Mobile phones	-	- -	-	-	*2,462*	94.0
Internet connected speakers	-	-	-	-	*277*	12.5
Tablets	-	- -	-	-	*1,696*	66.9
Electrical Cooling Equipment:						
Portable Fans	-	-	*1,146*	43.3	*1,319*	50.1
Other Fixed Fans	-	-	*232*	8.8	*148*	5.0
Fix Air Conditioning	-	-	*17*	0.8	*14*	0.7
Portable Air Conditioning	-	-	*50*	2.0	*44*	1.6
Humidifiers	-	-	-	-	*22*	0.8
Dehumidifiers	-	-	-	-	*57*	2.7
Extractor Fans	-	-	-	-	*131*	4.5

Base: all households (n=2,619 EFUS 1998, n=2,616 EFUS 2011, n=2,528-2,632, EFUS 2017) EFUS 1998, EFUS 2011 and Interview 1.

Note: '-' denotes that ownership of the appliance was not asked in 1998 or 2011, or not comparable with the 2017 data.

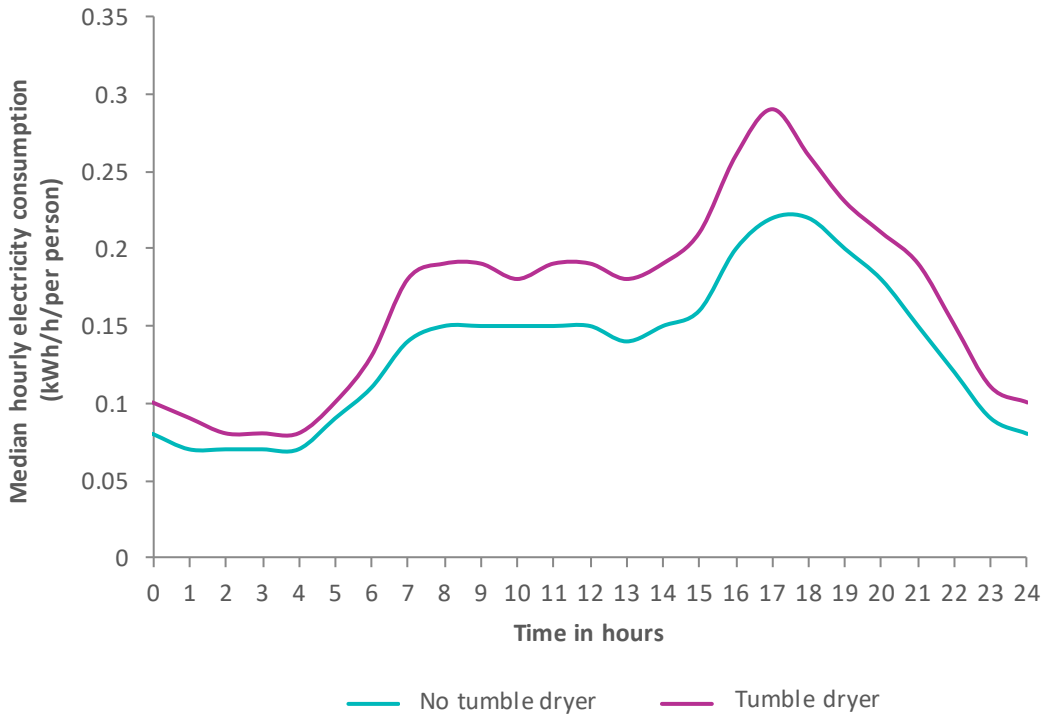
- Households with an HRP aged between 35-44 and 45-54 (99% for each category) were more likely to own a washing machine compared with households with an HRP aged 75 or over (94%) while households with an HRP aged between 45-54 and 55-64 (66% and 63% respectively) were more likely to own a tumble dryer compared with households with an HRP aged either between 16-34 (51%) or 75 or over (51%)
- Households with at least one person in employment (99%) were more likely to own a washing machine compared with those with no-one in employment (95%)
- Households in the fifth income quintile (67%) were more likely to own a tumble dryer compared with households in the first to third income quintiles (56%, 55%, 54% respectively)
- Households with at least one child present were more likely to own a washing machine (99%) or a tumble dryer (66%) compared with households without (97%, 56% respectively)
- Households without at least one member over state pension age (98%) were more likely to own a washing machine compared with those with (96%)
- Households under-occupying their home (64%) were more likely to own a tumble dryer compared with those not under-occupying (56%)

Washing machine ownership was more common than tumble dryer ownership across all groups, leading to the conclusion that a tumble dryer is considered more of a luxury appliance compared with a washing machine. This is supported by the result that households in the fifth (highest) income quintile were more likely to own a tumble dryer than any of the lower quintiles. A small proportion (3%) of households interviewed did not have a washing machine present in working order or in use. These households were likely to be living in flats with shared facilities and access to communal laundry facilities.

Comparison back to the 1998 EFUS shows a significant increase in the ownership of both washing machines and tumble dryers between 1998 and 2011. However, there was no significant change in either washing machine or tumble dryer ownership between the 2011 and 2017 EFUS.

Tumble dryers tend to be electrically intensive to run and therefore ownership and use of one can have a large impact on the electricity consumption of the household. Figure 4.1 shows the daily electricity profile for households who owned at least one tumble dryer and those that didn’t, normalised to household size to account for larger households which have higher consumption generally (Chapter 6 Section 6.3.1) and who were more likely to own at least one tumble dryer. Electricity consumption was higher throughout the day for those that owned at least one tumble dryer compared with those that did not. Although household size has been accounted for, there will be other factors driving the higher use along with tumble dryer ownership, such as floor area.

Figure 4.1: Median profile of mean hourly electricity consumption, 1st May 2018 to 30th April 2019, by tumble dryer ownership, normalised to household size



Base: all households (n=395) with electricity consumption data, main fuel not electric, and Interview 1.

4.1.2 Cold Appliances

For this analysis, households were identified as either owning at least one fridge/freezer or not. The type of fridge or freezer owned was not analysed by socio-economic characteristics. Households were classified as owning a fridge if they owned at least one of: fridge-freezer (with a large freezer), separate fridge (with small 'ice box' freezer), separate fridge (without small 'ice box' freezer) or an American style fridge-freezer. Households were classed as having a freezer if they owned at least one of: fridge-freezer (with large freezer), separate freezer or an American style fridge-freezer. With the categories collapsed into ownership of at least one type of fridge or freezer, 99% of households owned a fridge while 93% of households owned a freezer. However, ownership of freezers increased to 98% if fridges with ice-box freezer were also included as a freezer.

Analysis by socio-economic characteristics suggests that the following groups were more likely to own a freezer (not including ice-box freezers) than other categories in their group:

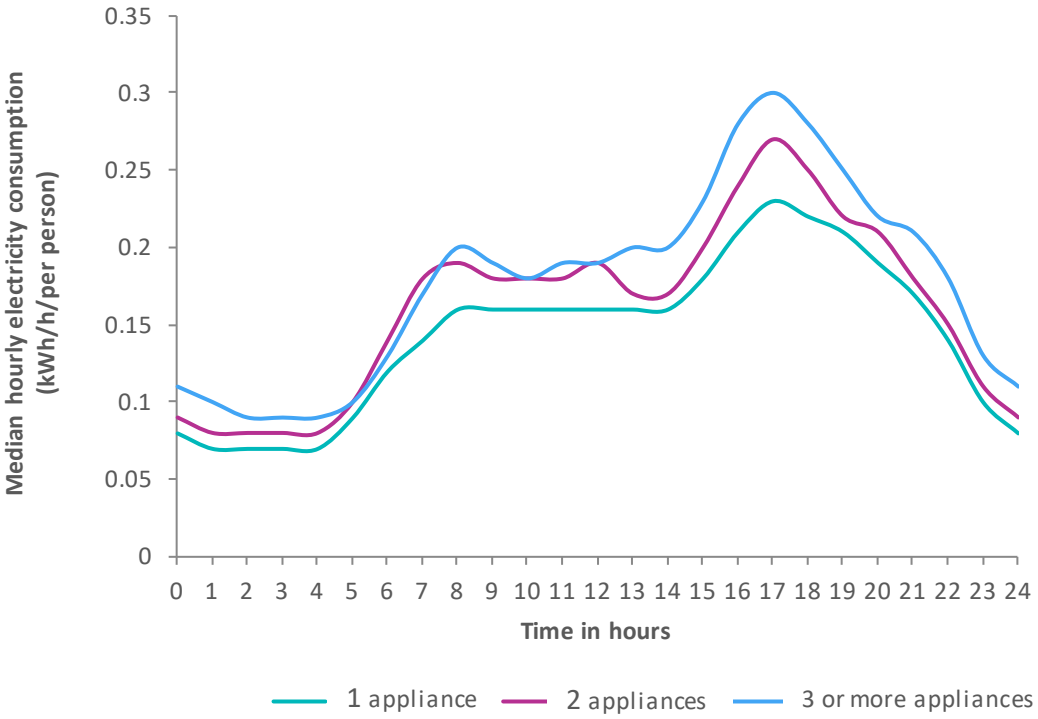
- Owner occupiers and housing association households (95% and 92% respectively) compared with private renters (86%)
- Households two or more occupants (ranging from 93% to 98% depending on size) compared with one-person households (88%). In addition, households with four occupants (98%) compared with households with two occupants (93%)

- Households with at least one child present (97%) compared with those without (92%)
- Households under-occupying their home (96%) compared with those not under-occupying (92%)

Comparison back to the 1998 and 2011 EFUS shows no significant change in either fridge or freezer ownership, however when split by appliance type, there was a significant decrease in ownership of separate freezers and separate fridges, and a significant increase in the ownership of fridge-freezers between 1998 and 2017, and between 2011 and 2017.

The number of cold appliances present in the household had a direct impact on the electricity consumption. Figure 4.2 shows how the daily electricity profile changed with the number of cold appliances a household owned, normalised to household size. Generally, higher consumption can be seen across the day as the number of cold appliances increased. This was particularly prominent in the early morning, afternoon and evening while during the late morning the consumption level was similar for households that owned two and three or more cold appliances, although both were higher than households that owned one cold appliance.

Figure 4.2: Median profile of mean hourly electricity consumption, 1st May 2018 to 30th April 2019, by number of cold appliances owned, normalised to household size



Base: all households (n=395) with electricity consumption data, main fuel not electric, and Interview 1.

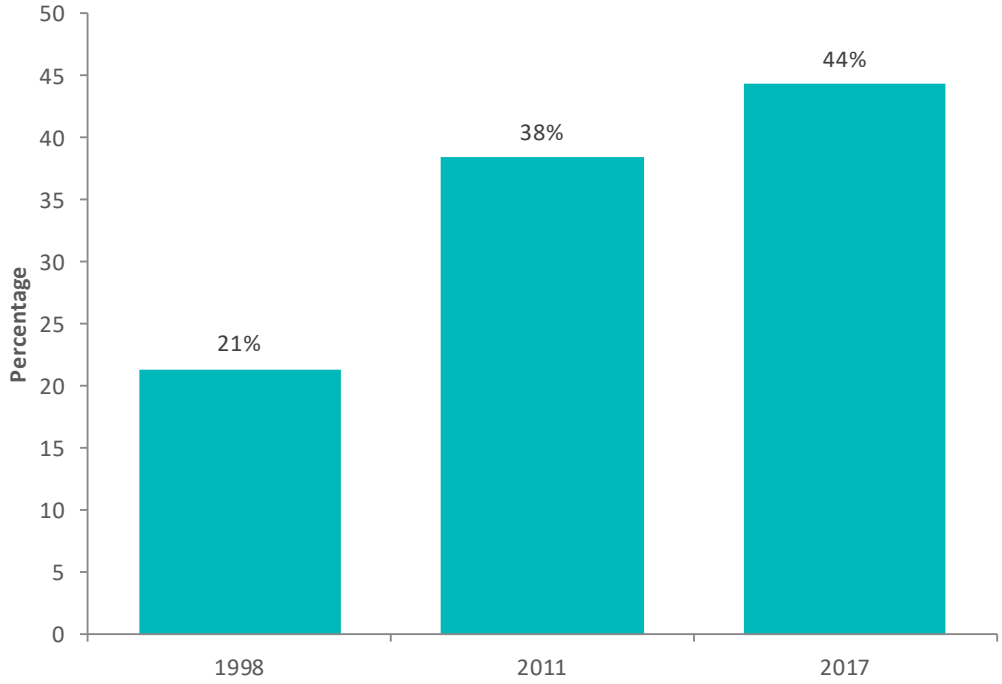
4.1.3 Dishwashers

Similar to tumble dryers, ownership of dishwashers (44%) was less common than other wet appliances, suggesting that they are also considered more of a luxury appliance. Analysis by socio-economic characteristics suggests that the following groups were more likely to own a dishwasher than other categories in their group:

- Owner occupiers (58%) compared with private renters (29%). In addition, private renters compared with local authority (12%) and housing association households (13%)
- Households in the fifth income quintile (74%) compared with households in the first to fourth income quintiles (24%, 32%, 38%, 53% respectively). In addition, significant differences were observed between all quintiles, except between the second and third quintile
- Households comprised of couples with or without children (ranging from 53% to 59% depending on category of couple) compared with households comprised of single adults (26% to 27% depending on age) and lone parents with dependent children (28%)
- Households with more than one person (ranging from 45% to 57% depending on size) compared with one-person households (27%)
- Households under-occupying their home (62%) compared with those not under-occupying (37%)
- Households with at least one person in employment (50%) compared with those with no-one in employment (34%)
- Households with an HRP aged between 35 and 74 (ranging from 46% to 51% depending on age band) compared with households with a younger (32%) or an older (37%) HRP
- Households that are not fuel poor (46%) compared with those in fuel poverty (32%)

Figure 4.3 shows dishwasher ownership has increased between the 1998 EFUS and the 2017 EFUS, from 21% in 1998, to 38% in 2011 and 44% in 2017.

Figure 4.3: Dishwasher ownership, 1998, 2011 and 2017



Base: all households (n=2,619 in 1998, n=2,616 in 2011, n=2,632 in 2017), EFUS 1998, EFUS 2011 and Interview 1.

4.1.4 Cooking Appliances

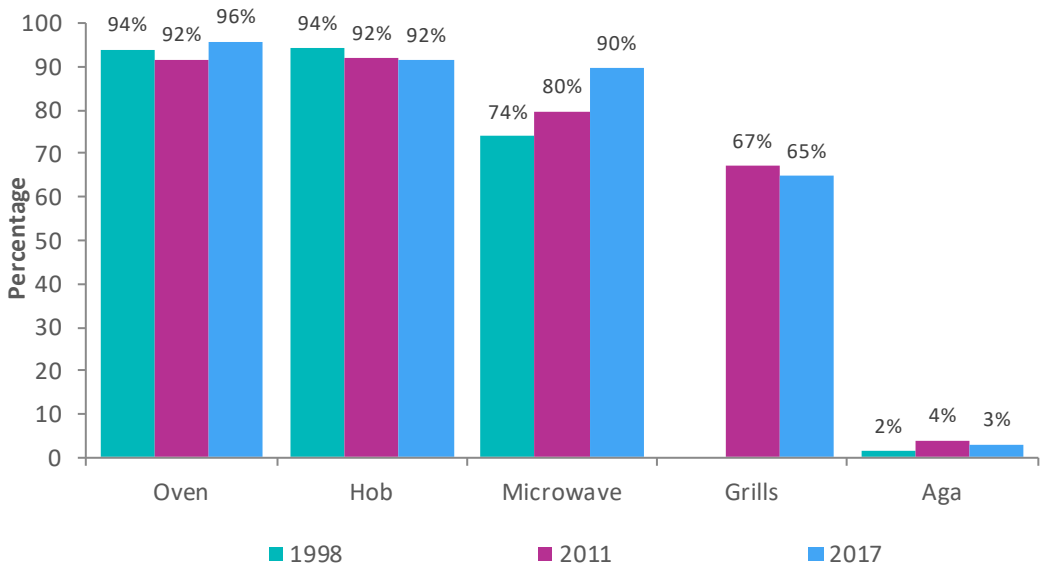
When asked about ownership of cooking appliances, householders specified both the appliance; oven, hob, grill, microwave, range cooker, and the fuel used; gas or electricity, for ovens, hobs, grills and range cookers. For analysis of ownership by socio-economic characteristics, cooking appliances were grouped by the type of appliance i.e. hob, oven etc. Analysis by fuel type is reported on in Section 4.2.2.

Most households owned ovens and hobs, 96% and 92%[9] respectively (Figure 4.4), with microwaves also present in the majority of households (90%). Other cooking appliances were less common; 65% of households reported owning a grill and just 3% reported owning an Aga/Rayburn style range cooker. Many modern ovens have an integral grill and therefore it is likely that the reported ownership of grills is an undercount of the true level of ownership.

Figure 4.4 shows ownership of cooking appliances as reported in the 1998, 2011 and 2017 EFUS. Ownership of microwaves has increased significantly between each survey. Between 1998 and 2011, the ownership of range cookers also increased significantly. Between 2011 and 2017, the ownership of ovens increased significantly.

Figure 4.4: Ownership of cooking appliances, 1998, 2011 and 2017[10]

[9] At Interview 1, 7% of cases (unweighted) with an oven did not report owning a hob. It may be assumed (in line EFUS 1998) that these households do have a hob which would increase the ownership of hobs to 97% (weighted).
[10] Respondents were not asked about grills in 1998.



Base: all households (n=2,619 EFUS 1998, n=2,616 EFUS 2011, n=2,632 EFUS 2017), EFUS 1998, EFUS 2011 and Interview 1.

Ownership of ovens, hobs, grill, microwaves and range cookers were analysed by socio-economic characteristics. Ownership of ovens and microwaves did not vary by household characteristics however the following groups were more likely to own hobs, grills and range cookers:

Hobs

- Owner occupiers and private renters (94% and 92% respectively) compared with local authority (84%) and housing association renters (83%)

Grills

- Households with an HRP aged 75 or over (72%) compared with households with an HRP aged between 35-44 (57%)
- Owner occupiers (67%) compared with private renters (57%)
- Households with at least one member over state pension age (69%) compared with those without (63%)

Range Cookers (Aga)

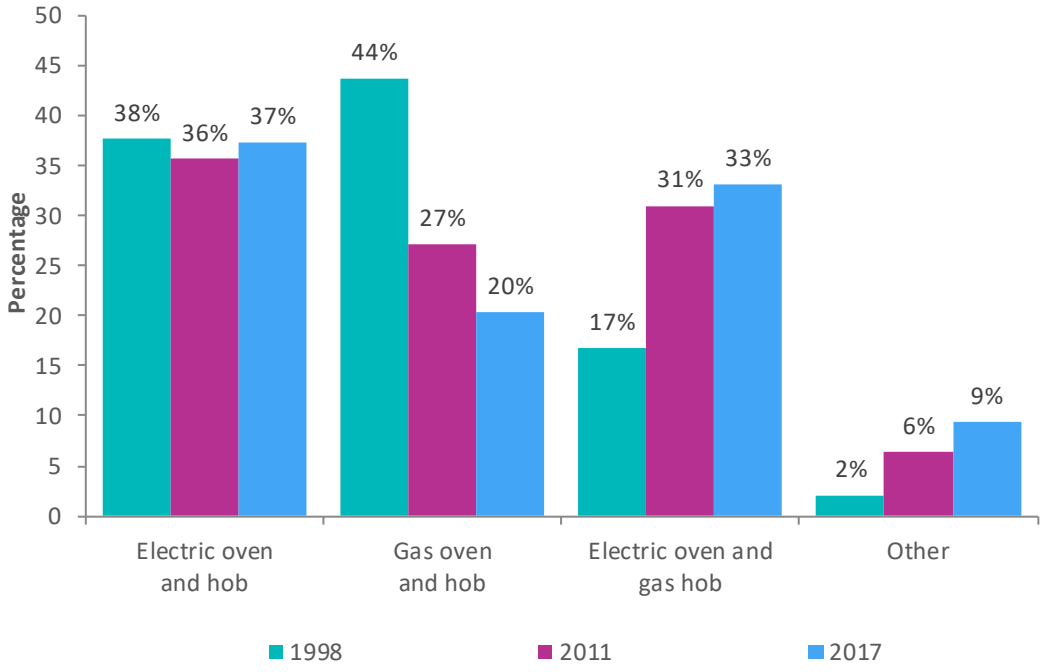
- Households under-occupying their home (6%) compared with those not under-occupying (2%)
- Households with at least one person in employment (4%) compared with households with no-one in employment (1%)

4.1.5 Cooking Appliance Combinations

Along with individual cooking appliance ownership, the most common combinations of ovens and hobs were examined. Figure 4.5 shows that the most common combination of oven and

hob fuel was electric oven and electric hob (37%), followed by electric oven and gas hob (33%) while 20% of households used gas for both their oven and hob. The remaining 9% had an alternative combination.

Figure 4.5: Ownership of common oven and hob combinations by fuel type



Base: all households (n=2,462 EFUS 1998, n=2,531 EFUS 2011, n=2,561 EFUS 2017), EFUS 1998, EFUS 2011 and Interview 1.

Analysis by socio-economic characteristics show that the following groups were more likely to own each combination:

Electric Oven and Electric Hob

- Housing association households (46%) compared with owner occupiers (35%)
- Households with no-one in employment (40%) compared with households with at least one person in employment (36%)
- Single person households aged under 60 or 60 years or over (46% and 45% respectively) compared with couples with dependent children (31%)
- One-person households (47%) compared with households with two, three or four occupants (35%, 34% and 27% respectively)
- Households with at least one member over state pension age (41%) compared with those without (36%)
- Households with an HRP aged 75 or over (47%) compared with households with an HRP aged between 35-44 and 45-54 (34% for both)

Electric Oven and Gas Hob

- Owner occupiers (41%) compared with private renters (31%). In addition, private renters compared with local authority (9%) or housing association households (7%)
- Households in the upper (fourth to fifth) income quintiles (38% and 44% respectively) compared with households in the lower (first to second) income quintiles (22% and 27% respectively)
- Households with at least one person in employment (37%) compared with households with no-one in employment (26%)
- Households comprised of couples of all ages, with or without dependent children (37%, 34%, 41% respectively) compared with households of one person aged 60 or over (22%)
- Households with two, three or four occupants (36%, 36% and 42% respectively) compared with one-person households (26%)
- Households without a member over the state pension age (35%) compared with those with (28%)
- Households under-occupying their home (38%) compared with those not under-occupying (31%)

Gas Oven and Gas Hob

- Local authority and housing association households (33% and 29% respectively) compared with owner occupiers (17%)
- Households in the first-, second- and third- income quintiles (24%, 26% and 21% respectively) compared with households in the fifth income quintile (12%)
- Households with no-one in employment (24%) compared with households with at least one member of the household in employment (19%)
- Households with a member over state pension age (23%) compared with households without (19%)

Timeseries analysis shows that there have been significant changes in the combinations of ovens and hobs, between the 1998, 2011 and 2017 EFUS. The proportion of households with a gas oven and gas hob has decreased over time, from 44% in 1998 to 20% in 2017. In contrast, the proportion of households with an electric oven and gas hob increased between 1998 and 2011, while the proportion of households with an electric oven and electric hob has remained the same over time (38% in 1998, and 37% in 2017).

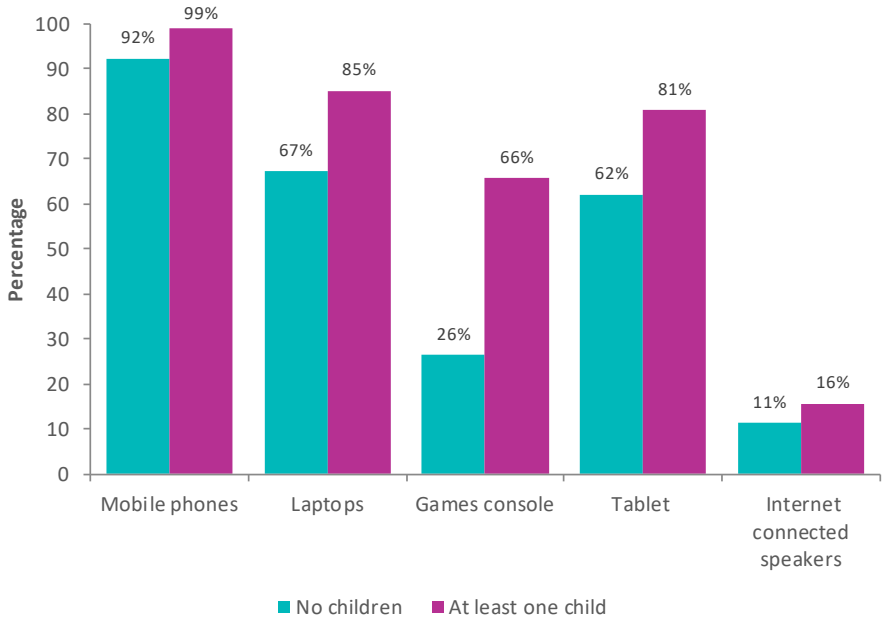
4.1.6 Electrical Entertainment Appliances

Analysis of TV ownership showed that the majority of households (96%) owned a TV. Those that did not own a TV were more likely to be private renters (92%), and more likely not to be under-occupying their homes (95%).

Analysis of ownership of other electrical entertainment devices: games consoles, laptops, mobile phones, tablets and internet connected speakers suggests that the age of occupants has a greater impact on ownership than other household characteristics. Households without a

member over state pension age were more likely to own the following appliances compared with those with a member over state pension age: games consoles (49% cf. 9%), laptops (81% cf. 52%), mobile phones (97% cf. 86%), tablets (73% cf. 53%) and internet connected speakers (15% cf. 8%). Equally, households with a younger HRP were more likely to own games consoles, laptops and internet connected speakers compared with households with an older HRP. Households with an HRP under the age of 74 were more likely to own mobile phones (92–98%) and tablets (64-75%) compared with households with an HRP aged 75 and over (79% and 38% respectively). Households with at least one child present were more likely to own games consoles, laptops, mobile phones, tablets or internet connected speakers compared with those without (Figure 4.6).

Figure 4.6: Electrical entertainment appliances by child present in the household

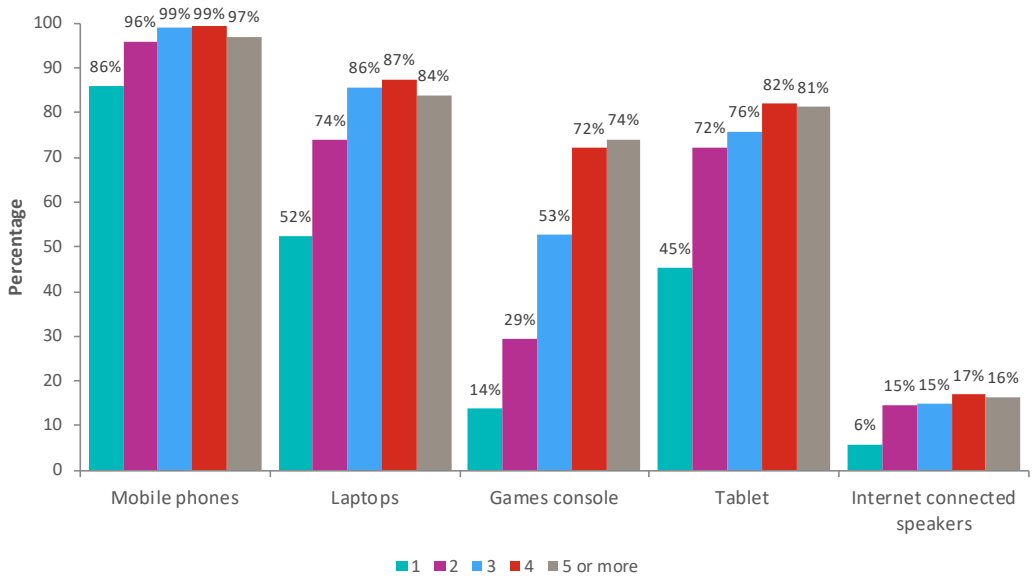


Base: all households (n=2,632 for mobile phones, laptops, games consoles and tablets, n=2,538 for internet connected speakers), Interview 1.

Number of occupants within a household also had an impact on ownership of electrical entertainment appliances; households with two or more occupants were more likely to own games consoles, laptops, mobile phones, tablets and internet connected speakers compared with one-person households (Figure 4.7).

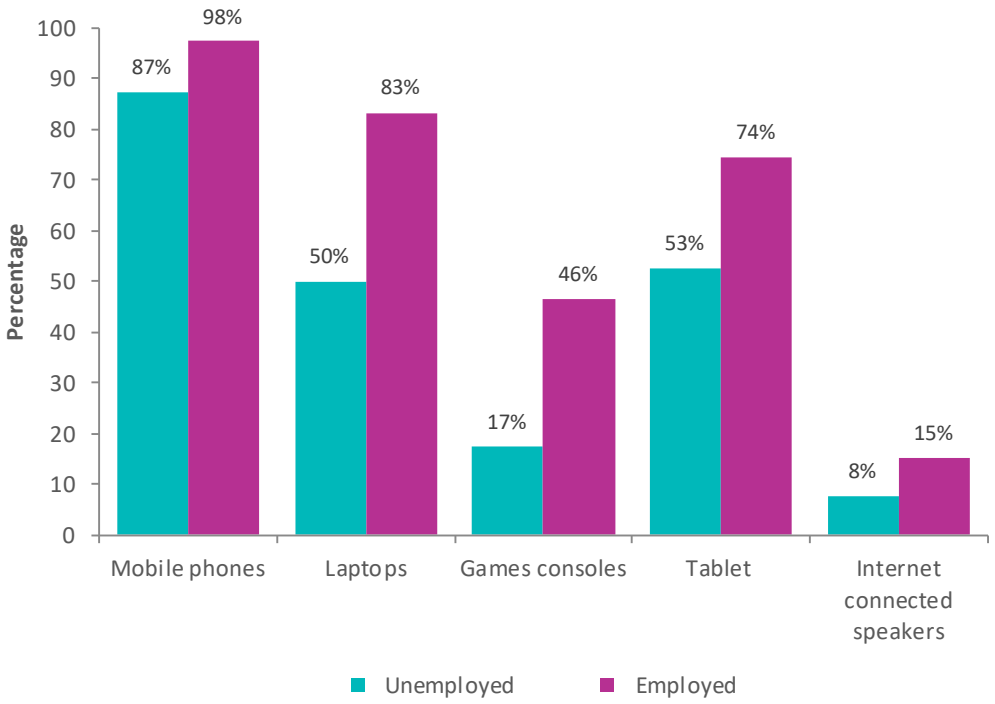
Employment status also had an impact an ownership of these entertainment devices, with households with at least one person in employment more likely to own games consoles, laptops, mobile phones, tablets and internet connected speakers compared with households with no-one in employment (Figure 4.8).

Figure 4.7: Electrical entertainment appliances by the number of occupants in the household



Base: all households (n=2,632 for mobile phones, laptops, games consoles and tablets, n=2,538 for internet connected speakers), Interview 1.

Figure 4.8: Electrical entertainment appliances by household employment status



Base: all households (n=2,632 for mobile phones, laptops, games consoles and tablets, n=2,538 for internet connected speakers), Interview 1.

In addition to the characteristics listed above, the following groups were more likely to own the following electrical entertainment devices:

Games Consoles

- Households not under-occupying their home (42%) compared with those under-occupying (22%)
- Households in the lowest income quintile (49%) compared with those in the third-, fourth- and fifth- income quintiles (34%, 31% and 27% respectively)
- Private renters and housing association households (44% and 43% respectively) compared with owner occupiers (33%)
- Households in fuel poverty (46%) compared with those not in fuel poverty (35%)

Laptops

- Owner occupiers and private renters (74% and 76% respectively) compared with local authority (55%) and housing association households (58%)
- Households in the fourth- and fifth- income quintiles (78% and 81% respectively) compared with those in the lower quintiles (ranging from 65% to 69%)

Mobile Phones

- Private renters (97%) compared with local authority (89%) and housing association households (91%)

Tablets

- Owner occupiers and private renters (71% and 66% respectively) compared with local authority (49%) and housing association households (55%)
- Households in the fifth income quintile (77%) compared with those in the first-, second- and third- income quintiles (ranging from 62% to 65%)

Internet Connected Speakers

- Owner occupiers (14%) compared with local authority (4%) and housing association households (7%)

Timeseries analysis shows that the proportion of households reporting owning and using a TV in 2017 has significantly decreased since the EFUS 2011 survey, from 98% of households in 2011 to 96% in 2017.

4.1.7 Energy Intensive Electrical Appliances

Energy intensive electrical appliances are classified as those that use large amounts of energy, generally electricity. These include aquariums, vivariums, greenhouse heaters, swimming pools, jacuzzis, saunas, patio heaters, workshop machinery and pottery kilns. Ownership of these devices is low amongst households (Table 4.2); however, it is important to know if any of these devices are present and used, as they will have a large effect on the electricity consumption.

In order to compare the ownership of any energy intensive electrical appliances across the different household groups, ownership across all such appliances was collated and households

that owned at least one energy intensive electrical appliance were identified[11]; amounting to 10% of all households.

Table 4.2: Ownership of energy intensive appliances

	Sample size	Percent (%)
Aquarium	*160*	6.1
Vivarium	*50*	1.6
Greenhouse heater	*33*	1.7
Heated swimming pool	*4*	*
Heated jacuzzi or hot tub	*27*	1.0
Sauna	*2*	*
Heavy workshop machinery	*28*	1.2
Electric patio heater	*16*	0.7
Electric pottery kiln	*4*	*
At least one energy intensive electrical appliance	*268*	10.3

Base: all households (n=2,515), Interview 1.

Note: * sample size too small to report on

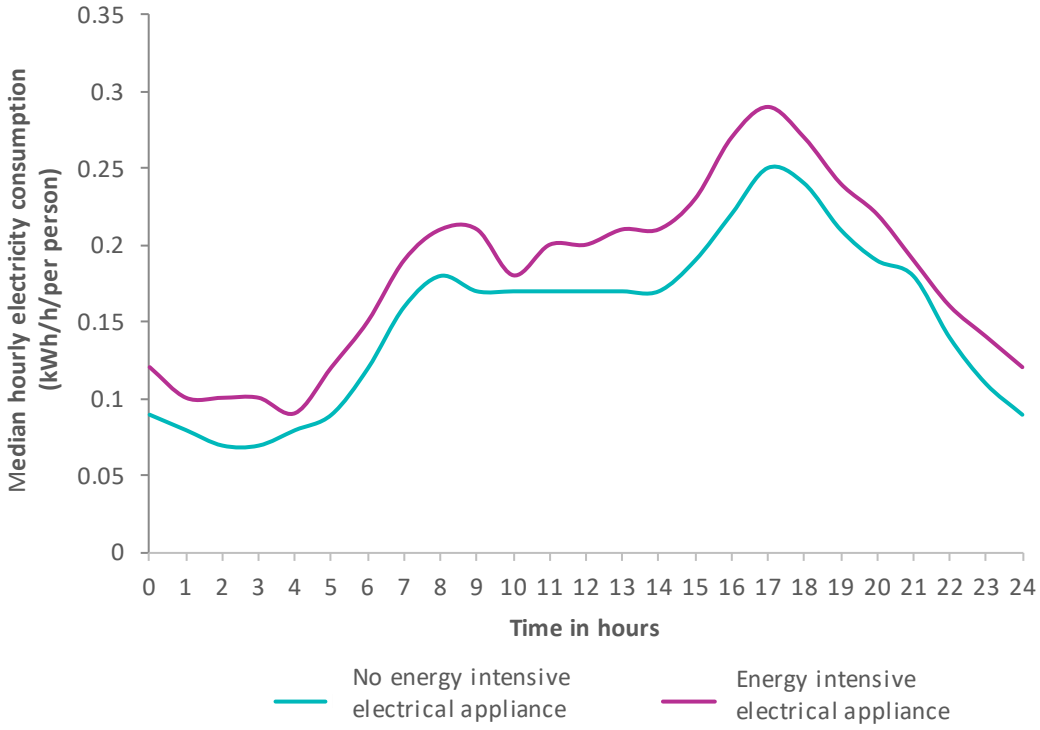
Ownership of at least one energy intensive electrical appliance was compared across socio-economic characteristics and the following groups were more likely to own at least one of these appliances:

- Households with five or more occupants (25%) compared with households with two or three occupants (9% and 13% respectively). In addition, households with two or three occupants compared with one-person households (5%)
- Household with at least one child present (17%) compared with those without (8%)
- Households without a member over state pension age (12%) compared with those with (7%)
- Households with at least one person in employment (12%) compared with those with no-one in employment (8%)

Ownership of an energy intensive electrical appliance would be expected to have a large impact on the electricity consumption of the household. Figure 4.9 shows the daily profiles of households that owned at least one energy intensive electrical appliance compared with those that did not, normalised to household size. The profiles show a similar shape, however households that owned an energy intensive electrical appliance had a higher level of consumption throughout the day, particularly over the afternoon and evening. The electricity load throughout the night was also larger. However, because of correlations with other factors linked to higher consumption, one cannot attribute the difference between these.

[11] Greenhouse heaters were excluded from this analysis as they could be powered by fuels other than electricity

Figure 4.9: Median profile of mean hourly electricity consumption, 1st May 2018 to 30th April 2019, by ownership of an energy intensive electrical appliance, normalised to household size



Base: all households (n=395) with electricity consumption data, main fuel not electric, and Interview 1.

4.1.8 Electrical Cooling Appliances

Households were asked to report which, if any, cooling devices they own. They were asked to specify the presence of any fans, air conditioning units, humidifiers, dehumidifiers and extractor fans. In total, 50% of households owned portable fans and 5% owned fixed fans, whilst only 2% of households owned portable air conditioning units and 5% owned extractor fans that they used for cooling.

Due to the low ownership of all electrical cooling devices, except for portable fans, analysis of ownership by socio-economic characteristics was carried out on ownership of at least one of the following cooling devices: portable fans, fixed fans, portable air conditioning units and fixed air conditioning units, enabling comparison with EFUS 2011.

Analysis by socio-economic characteristics shows that the following groups were more likely to own at least one electrical cooling device:

- Households with five or more occupants (71%) compared with households with two occupants (53%). In addition, households with two occupants compared with one-person households (44%)
- Households in the lowest income quintile (62%) compared with households in the third- and fifth-income quintiles (49% and 46% respectively)

- Households not under-occupying their home (56%) compared with those under-occupying (46%)
- Households without a member over state pension age (56%) compared with those with (46%)
- Households with at least one child present (61%) compared with those without (50%)
- Households with at least one person in employment (56%) compared with those with no-one in employment (48%)

Between 2011 and 2017, there has been a significant increase in the ownership of electrical cooling devices, increasing from 48% of households in 2011, to 53% in 2017.

4.2 Domestic Appliance Use

4.2.1 Use of Laundry Appliances

During Interview 2, which took place between January and April 2018, households were asked how many loads of washing were undertaken and how many loads of washing were dried in the tumble dryer during a typical week[12].

When analysing use by household characteristics, there was a significant difference in the number of loads washed and size of the household, with the median number of washing loads per week increasing with the number of people in the household, from two to seven loads for one-person households and households with five or more occupants, respectively (Table 4.3). Single person households and older households had a lower median number of washing loads compared with their counterparts. Households with at least one child present had a higher median number of washing loads compared with those without; increasing from three in households without children to five in households with at least one child present.

Households with at least one person in employment also had a higher median number of washing loads per week compared with those with no-one in employment. Households with a member over state pension age and households under-occupying their home had a lower median number of washing loads per week compared with their counterparts. Fuel poor households had a higher median number of washing loads per week; four, compared with three in non-fuel poor households.

Similar to the number of washing loads, the number of loads dried in a typical winter week increased with the size of the household (Table 4.4).

[12] Annex tables containing the underlying data for this section can be found in Tables_4_2.xls.

Table 4.3: Median number of loads of washing washed by household characteristics

	Median number of washing loads, washed		
	Sample size	Median	IQR for median (LQ, UQ)
Number of persons in the household:			
One	*347*	2.0	(1.0, 3.0)
Two	*472*	3.0	(2.0, 5.0)
Three	*191*	4.5	(3.0, 6.0)
Four	*168*	6.0	(4.0, 8.0)
Five or more	*76*	7.0	(6.0, 12.0)
Household composition:			
Couple, no dependent child(ren) under 60	*141*	4.0	(2.0, 5.0)
Couple, no dependent child(ren) aged 60 or over	*287*	3.0	(2.0, 5.0)
Couple with dependent child(ren)	*295*	5.0	(4.0, 7.0)
Lone parent with dependent child(ren)	*108*	4.0	(3.0, 6.0)
Other multi-person households	*74*	5.0	(3.5, 6.0)
One person under 60	*131*	2.0	(1.0, 3.0)
One person aged 60 or over	*218*	2.0	(1.0, 3.0)
Age of HRP:			
16 - 34	*115*	4.0	(2.0, 6.0)
35 - 44	*191*	4.0	(2.0, 6.0)
45 - 54	*265*	4.0	(3.0, 7.0)
55 - 64	*248*	3.0	(2.0, 5.0)
65 - 74	*281*	3.0	(2.0, 4.0)
75 years or older	*154*	2.0	(2.0, 4.0)
After housing costs equivalised income:			
1st quintile (lowest)	*316*	4.0	(2.0, 6.0)
2nd quintile	*287*	4.0	(3.0, 7.0)
3rd quintile	*205*	4.0	(2.0, 5.0)
4th quintile	*215*	3.0	(2.0, 5.0)
5th quintile (highest)	*231*	3.0	(2.0, 5.0)
Children present:			
No	*918*	3.0	(2.0, 4.0)
At least one child	*336*	5.0	(3.5, 7.0)
Employment status:			
Unemployed	*531*	3.0	(2.0, 4.0)
Employed	*723*	4.0	(2.0, 6.0)
Pensioner present:			
No	*784*	4.0	(2.0, 6.0)
Yes	*470*	3.0	(2.0, 4.0)
Under-Occupying:			
No	*886*	4.0	(2.0, 6.0)
Yes	*368*	3.0	(2.0, 4.0)
Fuel poverty:			
Non-fuel poor	*1,007*	3.0	(2.0, 5.0)
Fuel poor	*247*	4.0	(2.0, 7.0)

Base: all households (n=1,254) Interview 2.

Table 4.4: Median number of loads of washing dried by household characteristics

	Median number of washing loads, dried		
	Sample size	Median	IQR for median (LQ, UQ)
Number of persons in the household:			
One	*116*	2.0	(1.0, 3.0)
Two	*247*	2.0	(1.0, 4.0)
Three	*107*	3.0	(2.0, 6.0)
Four	*102*	5.0	(3.0, 7.0)
Five or more	*50*	6.0	(3.0, 10.0)
Household composition:			
Couple, no dependent child(ren) under 60	*77*	2.0	(1.0, 4.0)
Couple, no dependent child(ren) aged 60 or over	*163*	3.0	(1.0, 4.0)
Couple with dependent child(ren)	*177*	4.0	(3.0, 7.0)
Lone parent with dependent child(ren)	*50*	4.0	(2.0, 6.0)
Other multi-person households	*37*	3.0	(1.0, 5.0)
One person under 60	*45*	2.0	(1.0, 3.0)
One person aged 60 or over	*73*	2.0	(1.0, 3.0)
Tenure:			
Owner	*374*	3.0	(1.0, 4.0)
Private renter	*79*	3.0	(1.0, 5.0)
Local authority	*67*	5.0	(3.0, 7.0)
Housing association	*102*	3.0	(2.0, 7.0)
Age of HRP:			
16 - 34	*49*	3.0	(1.0, 6.0)
35 - 44	*86*	4.0	(2.0, 6.0)
45 - 54	*155*	3.0	(2.0, 6.0)
55 - 64	*133*	3.0	(1.0, 4.0)
65 - 74	*134*	2.0	(1.0, 3.0)
75 years or older	*65*	2.0	(1.0, 4.0)
After housing costs equivalised income:			
1st quintile (lowest)	*150*	4.0	(2.0, 5.0)
2nd quintile	*150*	3.0	(2.0, 6.0)
3rd quintile	*90*	3.0	(2.0, 5.0)
4th quintile	*108*	3.0	(1.0, 4.0)
5th quintile (highest)	*124*	2.0	(1.0, 4.0)
Children present:			
No	*431*	2.0	(1.0, 4.0)
At least one child	*191*	5.0	(3.0, 7.0)
Under-Occupying:			
No	*424*	3.0	(2.0, 5.0)
Yes	*198*	2.0	(1.0, 4.0)
Pensioner present:			
No	*406*	3.0	(1.0, 5.0)
Yes	*216*	2.0	(1.0, 4.0)
Fuel poverty:			
Non-fuel poor	*505*	3.0	(1.0, 5.0)
Fuel poor	*117*	4.0	(2.0, 6.0)
Employment status:			
Unemployed	*245*	2.0	(1.0, 4.0)
Employed	*377*	3.0	(1.0, 5.0)

Base: all households (n=622) Interview 2.

Households with dependent children had a higher median number of loads dried per week compared with households comprised of one-person or couples. Local authority households had a higher median number of loads dried per week compared with all other tenures[13]. Households in the highest income quintile had a lower median number of loads dried per week compared with those in the lower income quintiles. Households with at least one child present and households not under-occupying their home had a higher median number of loads dried compared with their counterparts. Households with a member over the state pension age had a lower median number of loads dried compared with those without. Households in fuel poverty had a higher median number of loads dried per week compared with non-fuel poor households, and households with at least one person in employment had a higher median number of loads dried compared with those with no-one in employment.

During interview 2, households were also asked to specify the time of day they typically used their washing machine and tumble dryer, with the options of morning, afternoon, evening and overnight given, as well as 'no typical time' and 'never'. The most common time of day that households used their washing machines was in the morning (48%), while 29% of households stated no particular time, 24% used their washing machine in the evenings, 17% in the afternoon and 7% stated overnight. For tumble dryers, 28% of households reported having no particular time preference, while 24% used their tumble dryers in the morning, 21% used their tumble dryers in the afternoon or the evening and only 5% of households used their tumble dryers overnight. In addition, 15% of households reported never using their tumble dryer in the winter.

Households that reported using their washing machine in the morning were more likely to be:

- Households comprised of couples aged 60 or over (68%) compared with households under 60 with no dependent children; both couples (38%) and one person (36%), and households with dependant child(ren); both couples (45%) and lone parents (35%)
- Households with an HRP aged 65 and over (65%) compared with households with an HRP aged between 16 and 64 (ranging from 37% to 47%)
- Households with a member over state pension age (64%) compared with those without (40%)
- Households with no-one in employment (57%) compared with those with (42%)

Households that reported using their washing machine in the afternoon were more likely to be:

- Households with an HRP aged 16-34 (25%) compared with those with an HRP aged 65-74 (11%) or those aged 75 or over (7%)
- Households without a member over state pension age (20%) compared with those with (10%)
- Households with at least one child present (23%) than those without (14%)

[13] The difference between Local authority and housing association households is at the 95% confidence interval.

Households that reported using their washing machine in the evening were more likely to be:

- Households with an HRP aged between 16 and 64 (ranging from 24% to 38% depending on age band) compared with households with an HRP aged 65 or over (ranging from 3% to 7% depending on age band)
- Households without a member over state pension age (32%) compared with those with (6%)
- Households with at least one person in employment (31%) compared with those with no-one in employment (10%)
- Households not under-occupying their home (29%) compared with those under-occupying (13%)
- Households with four occupants (36%) compared with those that have one, two or three occupants (22%, 21% and 20% respectively)
- Households with at least one child present (30%) compared with those without (22%)

Households that reported using their washing machine overnight were more likely to be:

- Households with at least one child present (12%) compared with those without (6%)
- Households without a member over state pension age (9%) compared with those with (4%)

Households that reported using their tumble dryer in the morning were more likely to be:

- Households comprised of couples aged 60 or over without dependent child(ren) (35%) compared with couples aged under 60 without dependent child(ren) (14%) and lone parents with dependent child(ren) (12%)
- Households with an HRP aged 75 or over (41%) compared with households with an HRP aged between 16 and 44 (ranging from 16% to 17% depending on age band)
- Households with at least one member over state pension age (32%) compared with those without (21%)

Households that reported using their tumble dryer in the evening were more likely to be:

- Households with an HRP aged 16-34 or 45-54 (36% and 30% respectively) compared with households with an HRP aged 65 or older (ranging from 7% to 8% depending on age band)
- Households comprised of couples with dependent child(ren) (33%) compared with couples aged 60 or over without dependent child(ren) (9%) and single person households aged 60 or over (9%)
- Households without a member over state pension age (27%) compared with those with (8%)
- Households with at least one person in employment (26%) compared with those with no-one in employment (11%)

- Households with four occupants (31%) compared with one-person households (14%)
- Households with at least one child present (30%) compared with those without (17%)
- Households not under-occupying their home (24%) compared with those under-occupying (15%)

There was no difference between groups for tumble dryer use in the afternoon and overnight. However, one-person households were more likely (26%) to report never using their tumble dryer compared with larger households with four occupants (7%).

Questions on use of washing machines and tumble dryers were also asked as part of the 1998 and 2011 EFUS. The median number of washing loads per week in both 1998 and 2011 was four. There was a significant decrease in the median number of weekly washing loads between 2011 and 2017 (from four to three). The median number of weekly loads of washing dried in 1998 was two, with a significant increase to three in 2011, and with no change in the number of tumble dryer loads between 2011 and 2017.

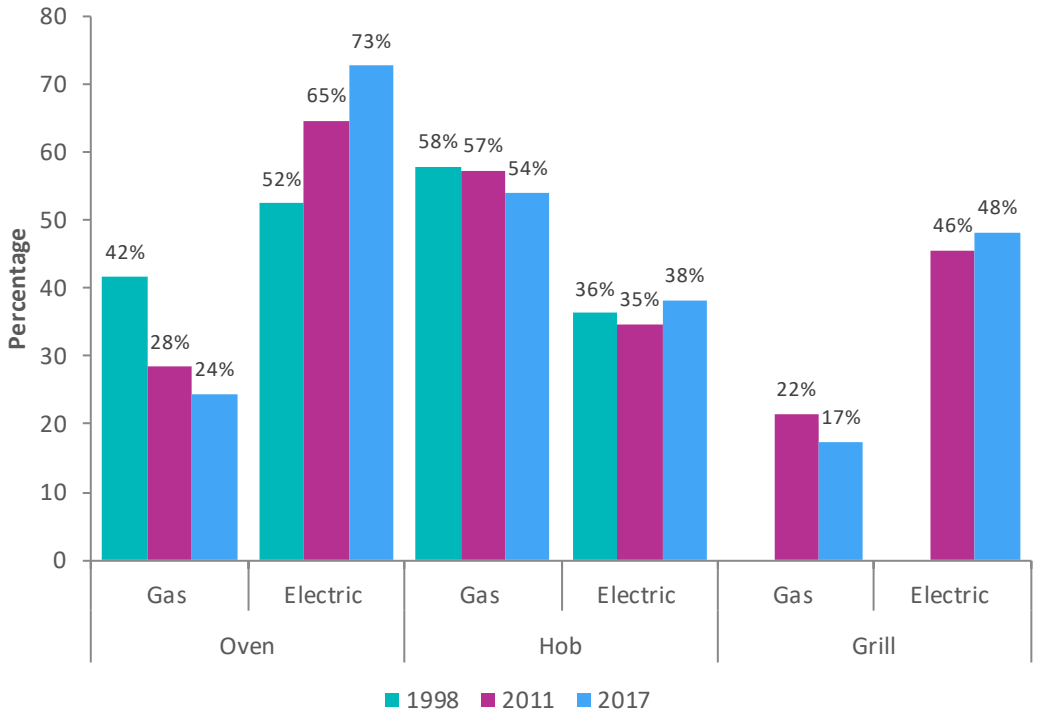
4.2.2 Cooking Fuels

The fuel used by different cooking appliances was also examined (Figure 4.10)[14]. In line with observations made in the 2011 EFUS, electricity was the dominant fuel used in ovens (73%) and grills (48%). However, a greater proportion of households used gas hobs (54%) compared with electric hobs (38%). There was a significant increase in the use of electricity as a cooking fuel between 1998, 2011 and 2017, increasing from 53% of households in 1998 to 75% of households in 2017.

Householders were also asked about the different types of fuel the Aga/Rayburn style range cooker used. Aga/Rayburn style range cookers will often use multiple fuels therefore households were able to pick as many fuels as appropriate out of a list of five; mains gas, electricity, solid fuel, oil and LPG/Calor gas. Over half of households with an Aga/Rayburn style range cooker used mains gas (56%) whilst 46% used electricity, and 28% used oil, however numbers were small for all these fuel types. Comparison back to the 1998 and 2011 EFUS shows that there was a significant increase in the use of mains gas between 1998 and 2017. Similarly, there was a significant increase in the use of electricity between 1998 and 2017.

[14] Annex tables containing the underlying data for this section can be found in Tables_4_2.xls.

Figure 4.10: Percentage ownership of cooking appliances by fuel type, 1998, 2011 and 2017[15]



Base: all households (n=2,619 EFUS 1998, n=2,616 EFUS 2011, n=2,632 EFUS 2017) EFUS 2017 Interview 1.

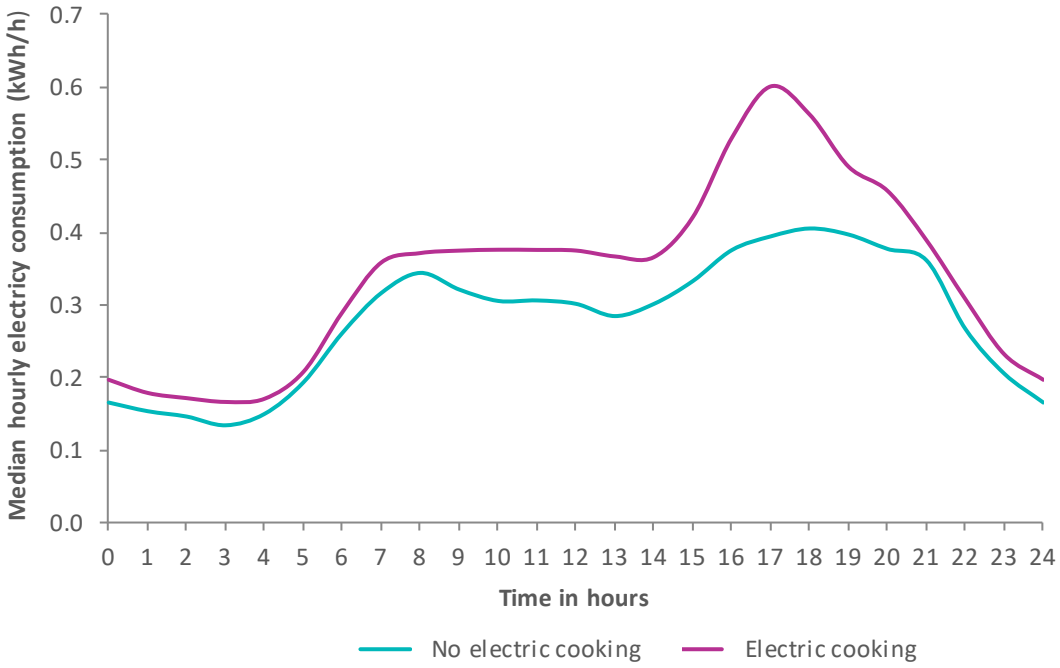
Analysis of cooking fuel by socio-economic characteristics shows that the following groups were more likely to own gas cooking appliances:

- Households with four occupants (71%) compared with households with two occupants (61%), and households with two occupants compared with one-person households (48%)
- Households comprised of a couple with dependent child(ren) (66%) compared with one-person households aged both over and under 60 (49% for both categories)
- Owner occupiers (62%) compared with local authority (50%) and housing association households (45%)
- The following groups were more likely to own electric cooking appliances:
- Owner occupiers and private renters (78% and 74% respectively) compared with local authority (59%) and housing association households (62%)
- Households in the fifth income quintile (84%) compared with those in the first-, second- and third- income quintiles (69%, 68% and 75% respectively)
- Households with at least one person in employment (77%) compared with those without (70%)

[15] Respondents were not asked about grills in 1998.

Figure 4.11 shows the daily profile of households who reported using electricity as their main cooking fuel compared with those that did not.

Figure 4.11: Median profile of mean hourly electricity consumption, 1st May 2018 to 30th April 2019, by households use of electric cooking



Base: all households (n=395) with electricity consumption data, main fuel not electric, and Interview 1.

Interestingly, the shapes of the profiles are quite different; households that used electricity as their main cooking fuel have a consistent level of consumption from the top of the morning peak (around 07:00) into the afternoon (around 14:00) whereas households that did not use electricity as their main cooking fuel see a slight drop in consumption over this period. Equally, whereas households that used electricity as their main cooking fuel have a defined peak in the evening (around 17:00), households that did not show a much flatter consumption profile over the late afternoon and evening.

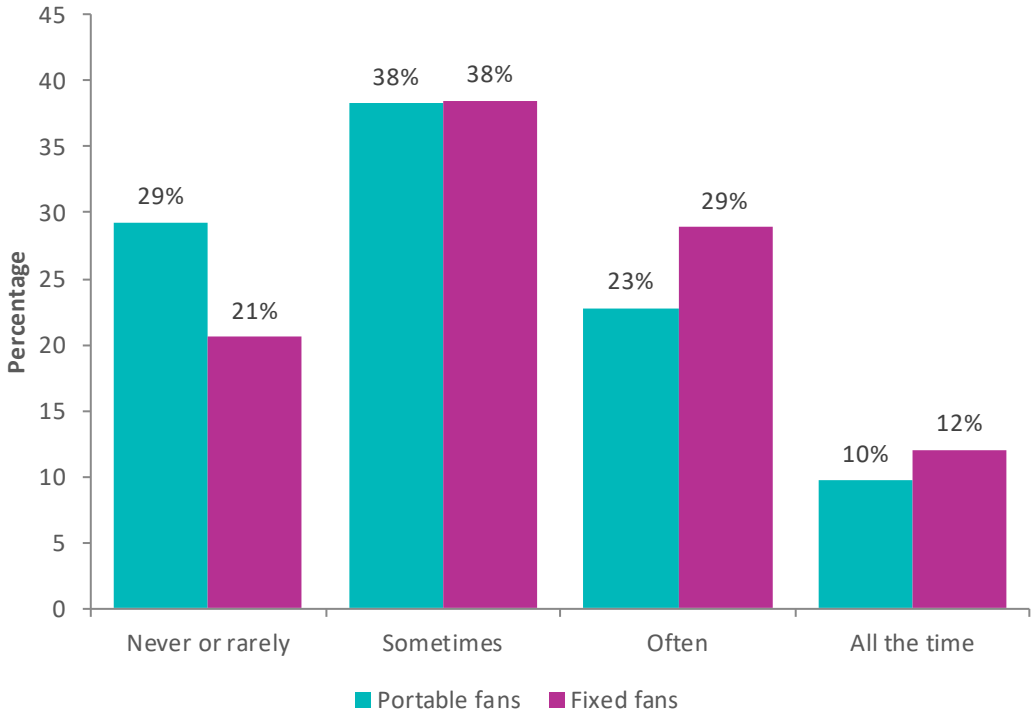
Other factors are likely to contribute to this evening peak, along with the presence of electric cooking appliances. In the EFUS electricity monitoring sample, 81% of households in a dwelling with over 90m2 of usable floor area reported using electric cooking appliances compared with 65% of households in a dwelling with a floor area less than 90m2, suggesting that households in larger dwellings were more likely to use electric cooking appliances. Linked to this, 84% of those in the electricity monitoring sample that reported using electric cooking appliances owned eight or more appliances compared with 46% of households that

owned seven or less, suggesting that households that reported using electric cooking appliances were also more likely to have more appliances in general[16].

4.2.3 Electrical Cooling Equipment Use

During Interview 1, which took place in the autumn of 2017, householders were asked both about ownership of electrical cooling equipment and how often they used their electrical cooling equipment during a typical summer, with the options of never, rarely, sometimes, often and all the time given[17]. Figure 4.12 shows the response for the two key cooling appliances; portable fans and fixed fans. 'Sometimes' was the most common level of usage for both cooling appliances.

Figure 4.12: Use of cooling appliances



Base: all households (n=1,264 portable fans, n=143 fixed fans), Interview 1.

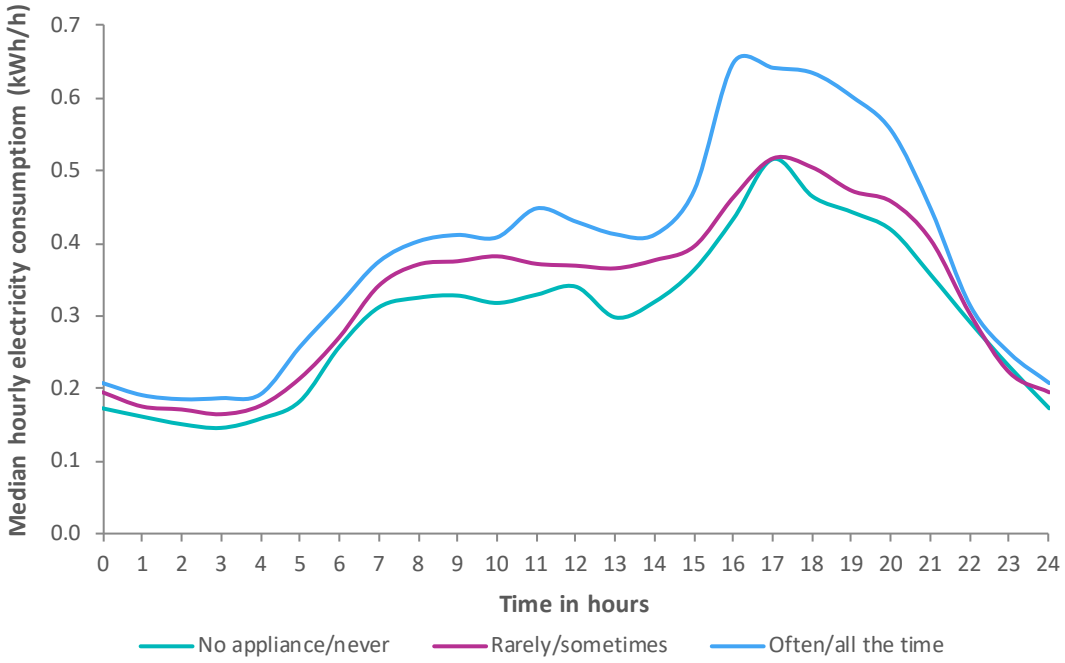
In addition to asking about usage of electrical cooling appliances during a typical summer, use of electrical cooling appliances was also asked during a particularly hot spell in July 2018. Of the householders that responded, 46% stated that they had used their electrical cooling appliances over the hot spell[18].

Figure 4.13 demonstrates how electrical cooling equipment use had an impact on household electricity consumption. There are two areas of noticeable difference between the consumption profiles, firstly the higher consumption throughout the late morning and early afternoon, which increases with frequency of use, but more marked is the difference during the evening peak.

[16] Percentages of the EFUS electricity monitoring sample are based on unweighted data.
[17] Annex tables containing the underlying data for this section can be found in Tables_4_2.xls.
[18] Results presented from the text survey responses are unweighted.

Households that use electrical cooling appliances, both rarely/sometimes and often/all the time, have a wider evening peak. In addition, households that report using electrical cooling equipment often/all the time use much more electricity throughout the evening, having a very steep increase around 15:00 and prolonged high levels of usage until late evening (between 20:00 and 21:00).

Figure 4.13: Median profile of mean hourly electricity consumption, 1st May 2018 to 30th April 2019, by use of electrical cooling equipment



Base: all households (n=371) with electricity consumption data, main fuel not electric, and Interview 1.

5. Smart Technologies

Given the rise in the ownership and use of smart in-home technologies, EFUS 2017 included a set of questions relating to ownership and use of smart home technologies such as smart lighting, smart appliances, and smart heating controls[19]. It is important to understand the uptake of smart home technologies in dwellings in order to identify occupants' choices and interaction with these technologies. Reported ownership of smart technologies is outlined below.

51 Smart Lighting Ownership

All households were asked to specify the number of smart lighting devices in their homes, if any. These include; Smart lamps, Smart bulbs and Smart lighting controls. Smart lamps and bulbs can be controlled individually, either by an app or a smart lighting console/remote. Smart lighting controls include these consoles/remotes, as well as additional controls, such as wireless dimmer switches, which allow the user to control multiple lights at once, i.e. for whole rooms. As the results in Table 5.1 demonstrate, only a low percentage of households owned smart lighting devices, with smart bulbs being the most common.

Table 5.1: Number of smart lighting and controls in the households

	Smart lighting and controls	
	Sample size	Percent (%)
Smart lamps	*13*	0.8
Smart bulbs	*44*	2.2
Smart lighting controls	*31*	1.8

Base: all households (n= 2,511), Interview 1.

In addition to ownership of smart lighting devices, households were asked if they used smart bulbs in the living room, kitchen, main bedroom or hallways/landings. Table 5.2 shows the distribution of smart bulbs in each of the four main rooms of the house, demonstrating that most households that own smart bulbs have them in their living room.

Table 5.2: Distribution of smart lightbulbs in each main room of the home

	Smart bulbs	
	Sample size	Percent (%)
Living room	*33*	83.3
Kitchen	*13*	34.7
Main bedroom	*16*	47.6
Hallway	*13*	37.5

Base: all households with a smart bulb (n=42), Interview 1.

[19] Annex tables containing the underlying data for this section can be found in Tables_5.xls.

Ownership of at least one of the above smart lighting devices; smart lamps, smart bulbs and smart lighting controls, was analysed by socio-economic characteristics and the following groups were more likely to own a smart lighting device:

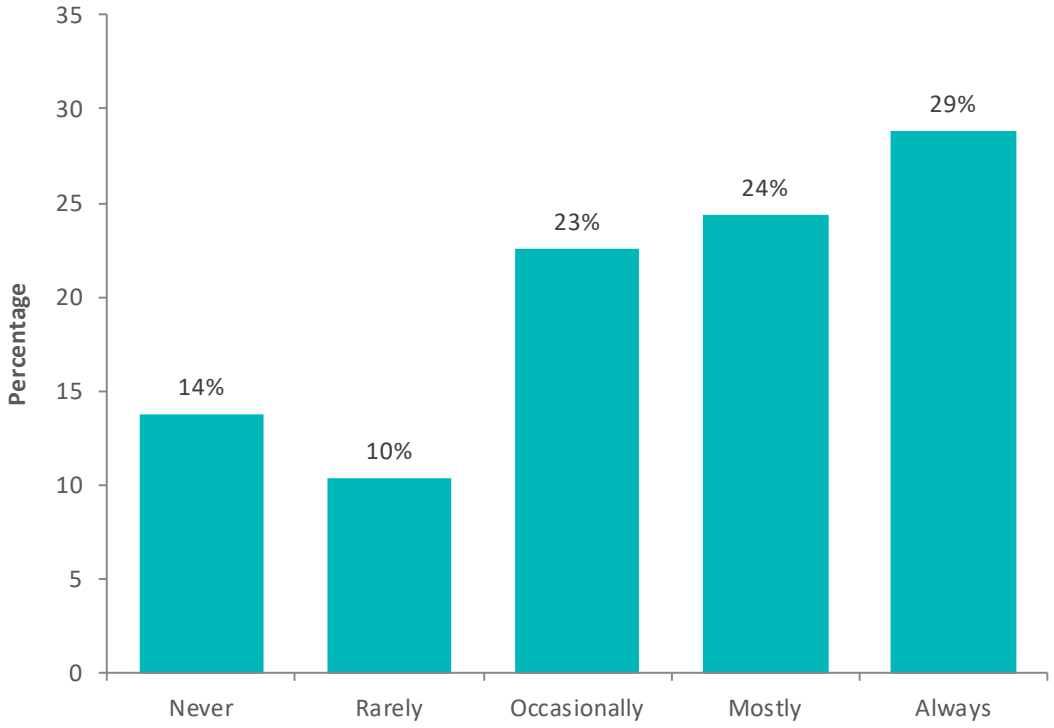
- Households without a member over state pension age (4%) compared with those with (2%)

During Interview 3, households were asked again if they owned any smart lighting devices; smart lamps, bulbs or controls; 2% of respondents reported owning smart lamps, 5% owned smart bulbs and 3% owned smart lighting controls. Ownership of a least one smart lighting device increased significantly between Interview 1 and Interview 3, from 3% to 7% respectively.

5.2 Smart Lighting Use

Households with smart lighting were asked to specify how often they used their smart lighting controls. A higher proportion of households with smart lighting controls reported to 'always' use smart controls to adjust the lighting in their home over adjusting the lighting manually (Figure 5.1).

Figure 5.1: Frequency of use of smart lighting



Base: All households that owned a type of smart lighting (n=64), Interview 1.

Households with smart lighting were also asked how the installation of smart lighting had affected the length of time they use their lighting. In total, 64% of households reported to have their lights on for about the same amount of time as before installing smart lighting, while 26% reported to have the lights on less.

5.3 Smart Appliances

Smart appliances were defined, for the purpose of this study, as 'an appliance with internet connectivity'. If a household reported the presence of a TV, digital TV box or any of the nine possible wet or cold appliances, they were asked how many of these were internet connected. Households were also asked how many internet connected speakers they owned. The most common smart appliance owned was an internet connected digital TV box, with 81% of households owning at least one, while 55% owned at least one internet connected smart TV. Other smart appliances were less common (Table 5.3).

Table 5.3: Ownership of smart appliances

	Smart appliances	
	Sample size	Percent (%)
Internet connected smart TVs	*1,306*	55.0
Internet connected digital TV boxes	*1,440*	80.5
Internet connected speakers	*277*	12.5
Kitchen appliances internet controlled/controlled remotely	*35*	1.4

Base: all households (n=2,461 smart TV, n=1,820 internet connected digital TV box, n=2,538 internet speakers, n=2,627 kitchen appliances), Interview 1.

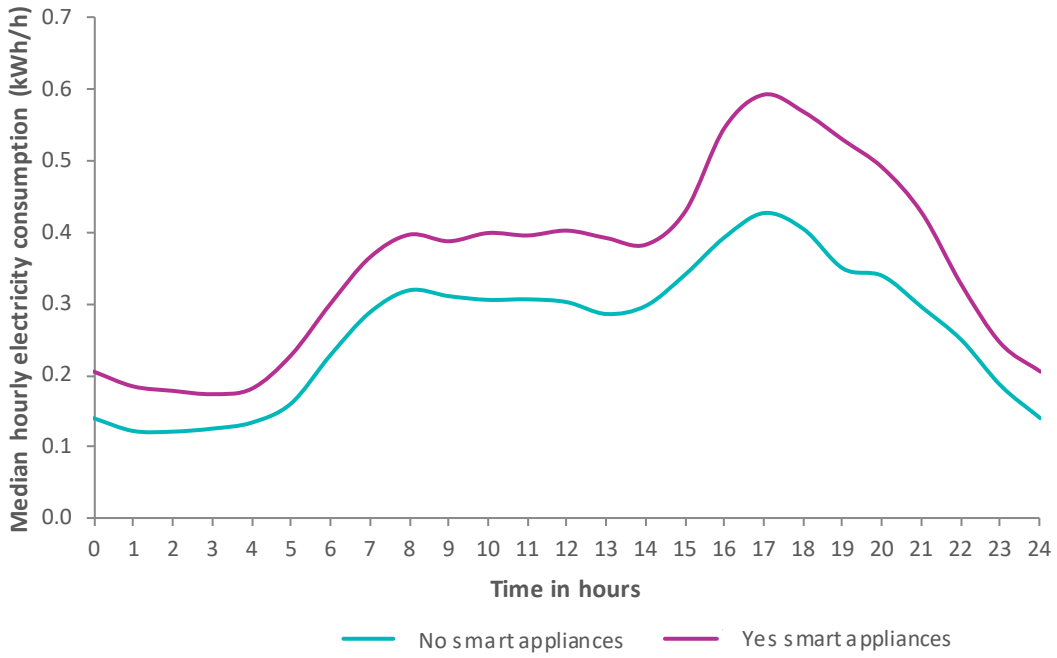
- Analysis by socio-economic characteristics shows that the following groups were more likely to own at least one smart appliance:
- Households with three or four occupants (82% and 86% respectively) compared with households with two (73%). In addition, households with two occupants compared with one-person households (57%)
- Households with at least one person in employment (78%) compared with those with no-one in employment (61%)
- Households without a member over state pension age (77%) compared with those with (62%)
- Households with at least one child present (83%) compared with those without (69%)
- Owner occupiers (76%) compared with private renters (66%) and social renters (60% local authority, 65% housing association)

During interview 3, households were once again asked if they owned a smart digital TV box or smart TV; 69% of respondents reported owning smart digital TV box, while 53% reported owning a smart TV. Households were also asked to report ownership of any smart kitchen appliances in the home. Again, ownership was low, with only 2% of households reporting owning a smart kitchen appliance.

Figure 5.2 shows how ownership of smart appliances affects electricity consumption throughout the day. The median daily profile of households that owned at least one smart appliance is compared with the median daily profile of those that did not. Households that owned at least one smart appliance have higher electricity consumption throughout the day, with the largest difference seen in the evening. The rise in consumption at the start of the

evening peak is much steeper, with a similar rate of drop off to those that did not own any smart appliances, leading to a much higher level of consumption throughout the evening. It is also worth noting that electricity consumption through the night/early morning is higher for those that owned smart appliances.

Figure 5.2: Median profile of mean hourly electricity consumption, 1st May 2018 to 30th April 2019, by ownership of smart appliances



Base: all households (n=379) with electricity consumption data, main fuel not electric, and Interview 1.

5.4 Meters, displays and heating controls

During Interview 1, all households were asked whether they had a smart electricity and/or gas meter in their home. A smart electricity/gas meter was defined as a meter that 'automatically sends electricity/gas meter readings to your energy supplier, so you don't have to take readings anymore'. A total of 25% of households reported that they had a smart electricity meter and 24% of households with gas reported that they had a smart gas meter at their home. In total, 27% of households reported owning a smart gas or electricity meter at Interview 1, increasing to 36% of households at Interview 3.

Ownership of smart electricity meters was compared between different household groups. The only difference observed was in tenure, where private renters (17%) were less likely to own smart electricity meters compared with owner occupied, local authority and housing association households (26%, 32% and 30% respectively).

Ownership of smart gas meters was also compared between different household groups. Again, the only difference was observed between tenure with housing association and local

authority households (31% for both) more likely to own smart gas meters compared with private renters and owner occupied households (19% and 23% respectively).

Householders were asked to specify whether they owned an energy display that shows the energy use in their homes. For the purposes of the survey, respondents were told 'an energy display is often provided with smart meters, and lets you see how much electricity and/or gas you are using, either on a separate energy display, on a mobile phone app, or online'.

Of those households that stated that they own a smart meter, 78% reported an energy display in the household. Of those asked about smart display ownership: 76% had a home display/separate screen that shows household energy use; 4% used a mobile phone app; and 3% had an online display which shows household energy use (Table 5.4). As with ownership of smart meters, the only difference in ownership between household groups was observed for tenure where private renters (14%) were less likely to own a smart meter with an energy display compared with owner occupied, local authority and housing association households (23%, 30% and 26% respectively).

Table 5.4 Ownership of smart energy displays

	Smart energy displays	
	Sample size	Percent (%)
In home display/separate screen that shows household energy use	*561*	75.6
Mobile phone app that shows household energy use	*35*	4.2
Online display that shows household energy use	*22*	2.9

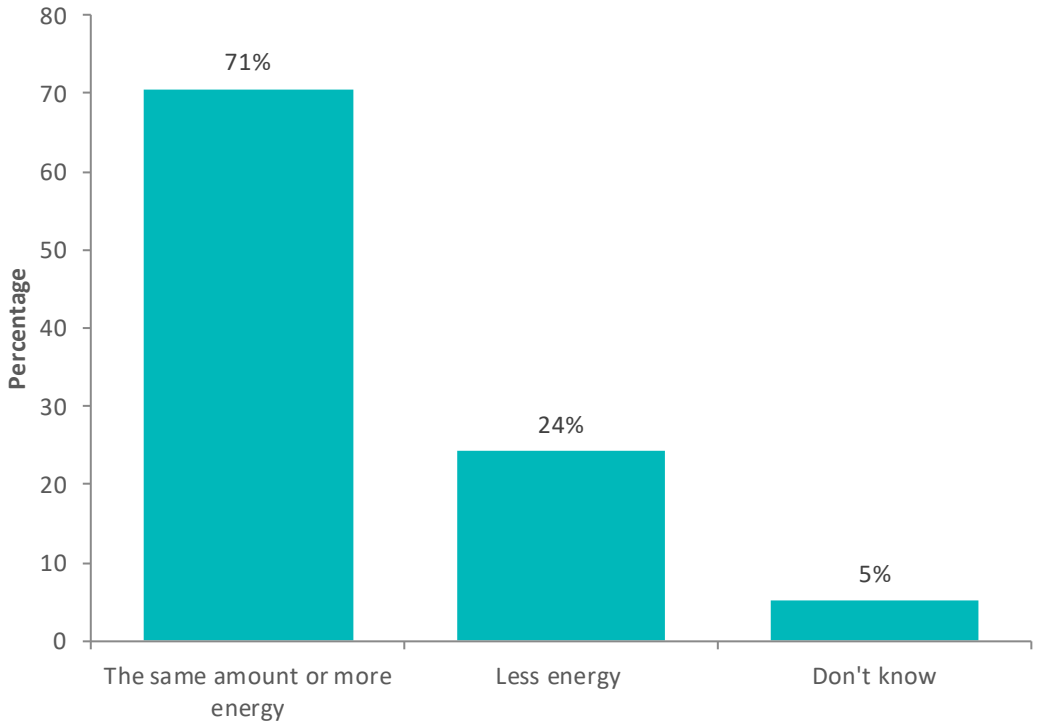
Base: all households with a smart meter (n=734), Interview 1.

The households that owned an energy display were asked to assess how ownership of the energy display had affected their energy use. A total of 24% of households reported that they were using less energy than before installing a smart display (Figure 5.3), while most households (68%) reported using the same amount and only 2%[20] of households reported using more energy than before installing a smart display.

In line with most households reporting using the same amount of energy following installation of a smart display, comparison between median daily electricity profiles of households that owned smart displays and those that did not (Figure 5.4) showed little difference throughout the day.

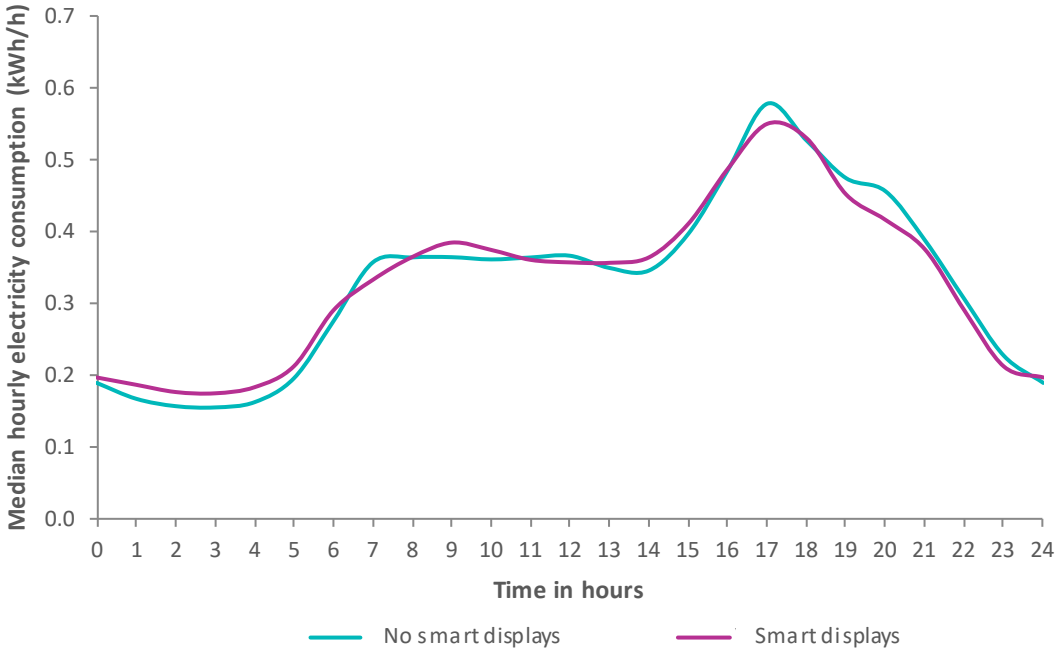
[20] Inconsistencies between reported percentages for households who reported using 'more' and 'the same amount' within the text and Figure 5.3 are due to rounding

Figure 5.3: Energy use following installation of smart energy display



Base: all households with a smart meter and smart energy display (n = 579), Interview 1.

Figure 5.4: Median profile of mean hourly electricity consumption, 1st May 2018 to 30th April 2019, by ownership of smart displays

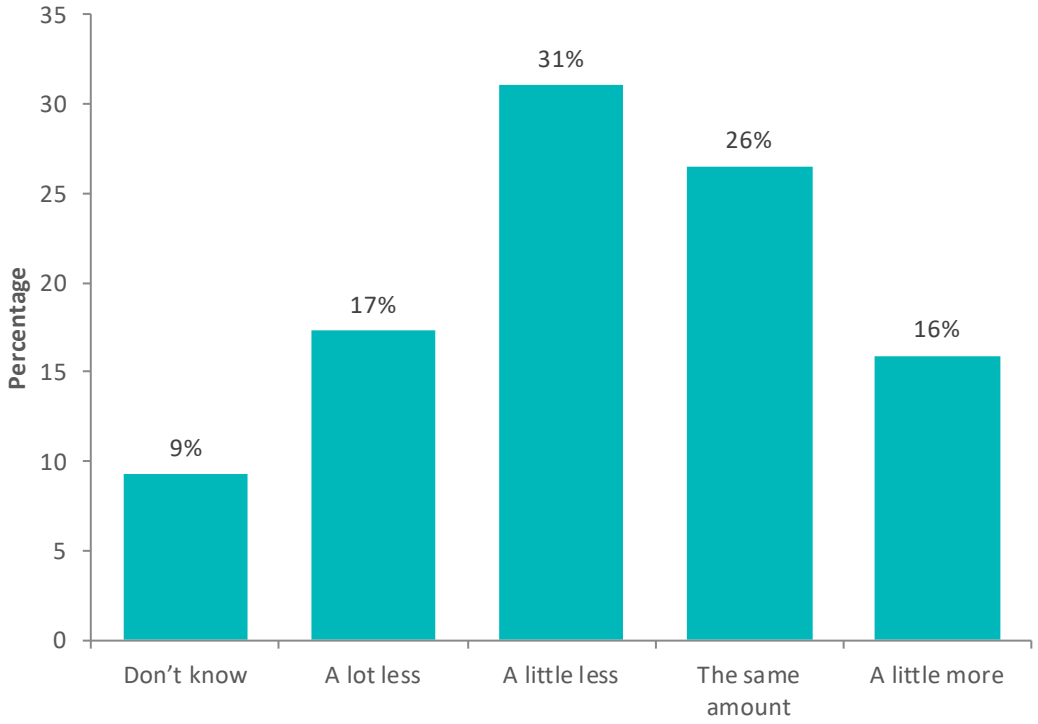


Base: all households (n=373) with electricity consumption data, main fuel not electric, and Interview 1.

During interview 2, householders with central heating were asked whether they owned a smart heating control that 'allows you to control your heating remotely using a mobile phone, tablet, or computer?'. Ownership of smart heating controls was low with only 8% of households reporting that they had smart heating controls. Of these households, 45% owned a 'Hive' system, 19% a 'Nest' system, whilst 30% reported owning another type of smart heating or control and 7% did not know the type.

Of the households that owned smart heating controls, 66% reported using them as their main method of controlling their central heating. Households that owned smart heating controls were also asked how owning smart heating controls had affected their heating use. Households most commonly reported that they used their heating 'A little less' (31%), Figure 5.5; the smart heating control made the home a little more comfortable (36%) and the smart heating control is very easy to use (64%). In addition, 36% of households reported that their energy bills were a little lower since using the smart heating control, however 32% reported they were the same amount and 23% reported they did not know the impact on their energy bills.

Figure 5.5: Energy use following installation of smart heating controls[21]



Base: all households with smart heating controls (n = 73), Interview 2.

At Interview 3, 9% of households reported owning a smart heating control. Of these households, 73% reported that they used their smart heating controls to control their central heating.

[21] The 'don't know' category was included in this table as it was considered a valid response category.

Analysis by socio-economic characteristics shows that the following groups were more likely to own smart heating controls at Interview 3:

- Households in the highest income quintile (18%) compared with those in the first- and third- income quintiles (4% and 5% respectively)
- Households without a member over state pension age (11%) compared with households with (5%)

5.5 Energy efficiency measures, energy storage and micro-generation

Householders were asked questions about ownership of micro-generation and energy storage measures as part of Interview 1 which have an impact on reducing electricity through the metered supply. Households that owned PV were identified and asked to specify if they changed their appliance use habits to run them when it is sunny. A total of 4% of households reported they had PV on the day of the interview. Out of the respondents that had PV present, 54% of people reported that they had changed the time that they run appliances to coincide with when the PV panels are generating electricity.

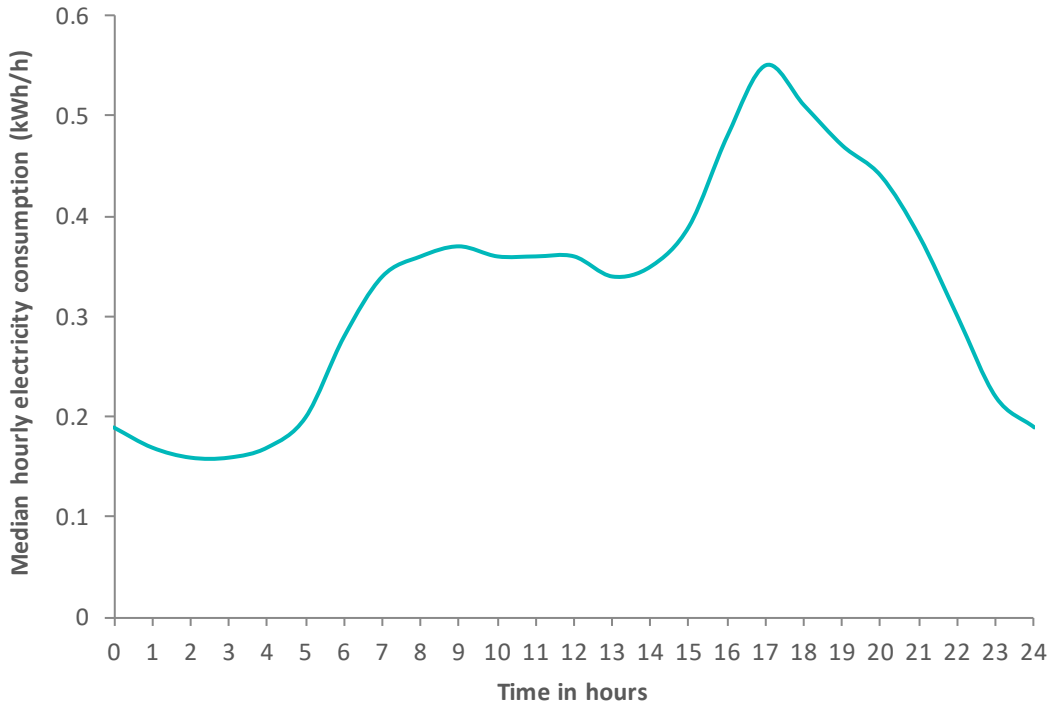
6. Analysis of Electrical Consumption

This chapter uses the electricity consumption data to report average energy consumption profiles, identify peak usage times and investigate variations in household electricity usage between different household types and socio-economic characteristics. Analysis will cover electricity consumption data collected between May 2018 and April 2019. Where households reported using electricity as their main heating fuel, their consumption data has been removed from the main sample and analysed separately.

6.2 Current Domestic Electricity Consumption

Figure 6.1 shows the median electricity consumption for each hour in the day, referred to as the daily consumption profile, across all sites. Hours 0 and 24 are both reported but are the same, which is the case for all daily profiles presented in this report.

Figure 6.1: Median profile of mean hourly electricity consumption, 1st May 2018 to 30th April 2019

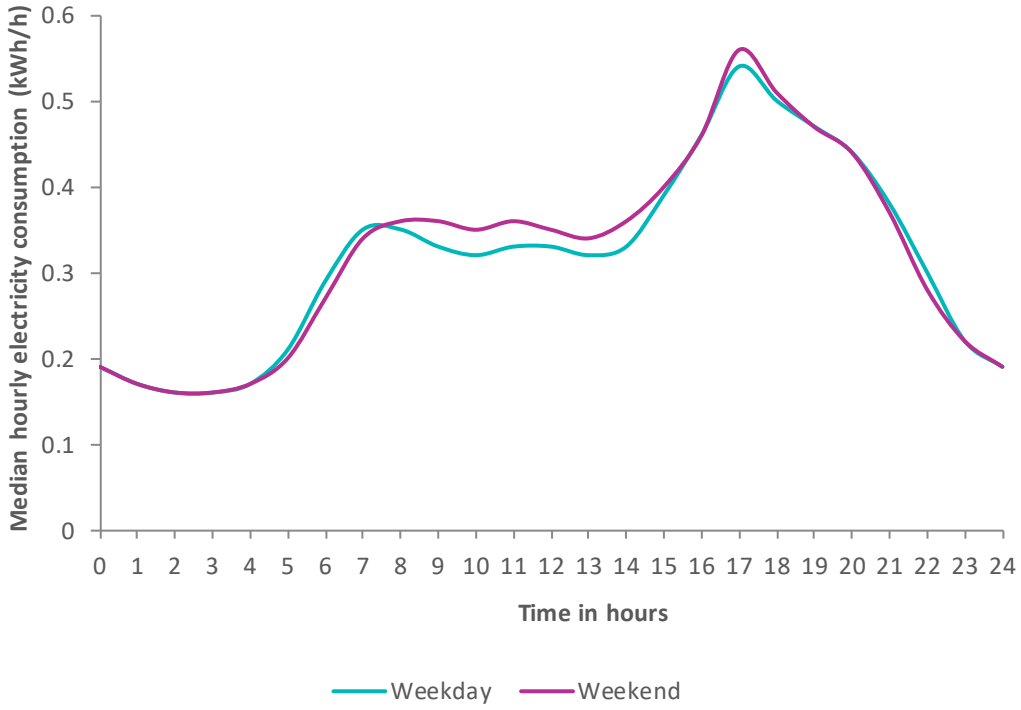


Base: all households (n=395) with electricity consumption data, main fuel not electric.

The base level of consumption started at around 0.2 kWh, before decreasing slightly between midnight and 4:00. Consumption then increased over the morning period, between 5:00 and 8:00, before plateauing during the day. Consumption increased again between 15:00 and 17:00, reaching a daily maximum just after 17:00, before decreasing again between 17:00 and midnight.

Figure 6.2 shows the difference in median daily consumption between weekdays and weekends.

Figure 6.2: Median profile of mean hourly electricity consumption for weekdays and weekends, 1st May 2018 to 30th April 2019

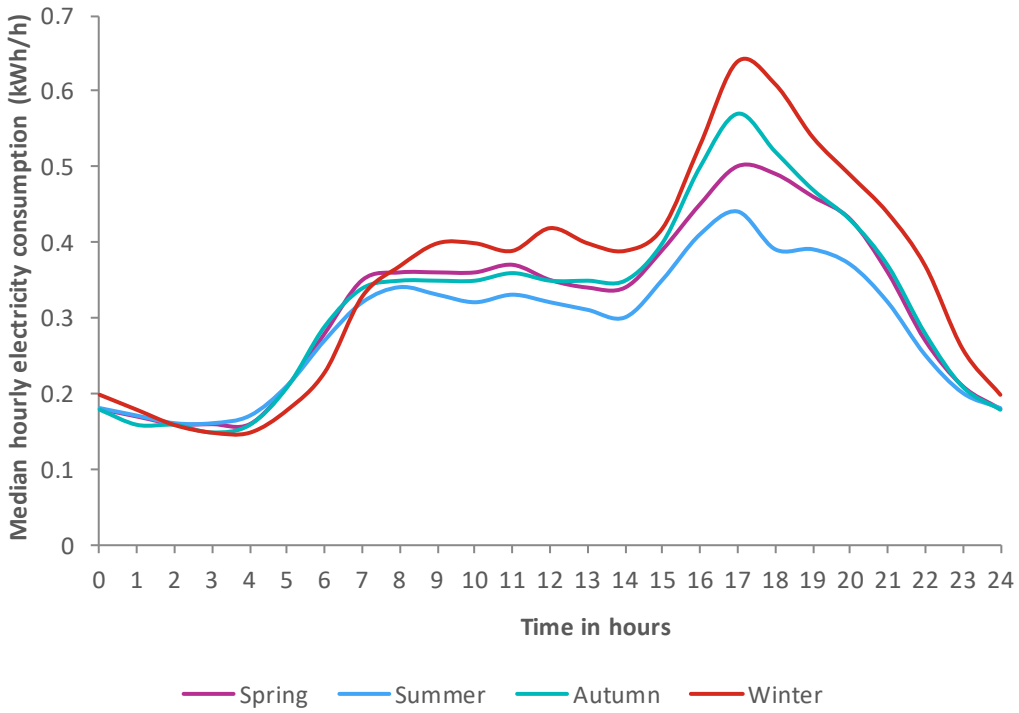


Base: all households (n=395) with electricity consumption data, main fuel not electric.

The daily consumption profiles of weekdays and weekend days varied very little. The morning increase in electricity consumption occurred slightly later for weekend days, and a higher level of electricity consumption was maintained throughout the late morning and early afternoon. The increase in consumption in the evening occurred around the same time with peak evening consumption slightly higher at the weekend but decreasing around the same time and at a similar rate.

Although there was no clear difference between the electricity consumption profiles on different days of the week, profiles changed between times of year. The differences in daily consumption profiles between different seasons; winter (December, January, February), spring (March, April, May), summer (June, July, August) and autumn (September, October and November) are shown in Figure 6.3.

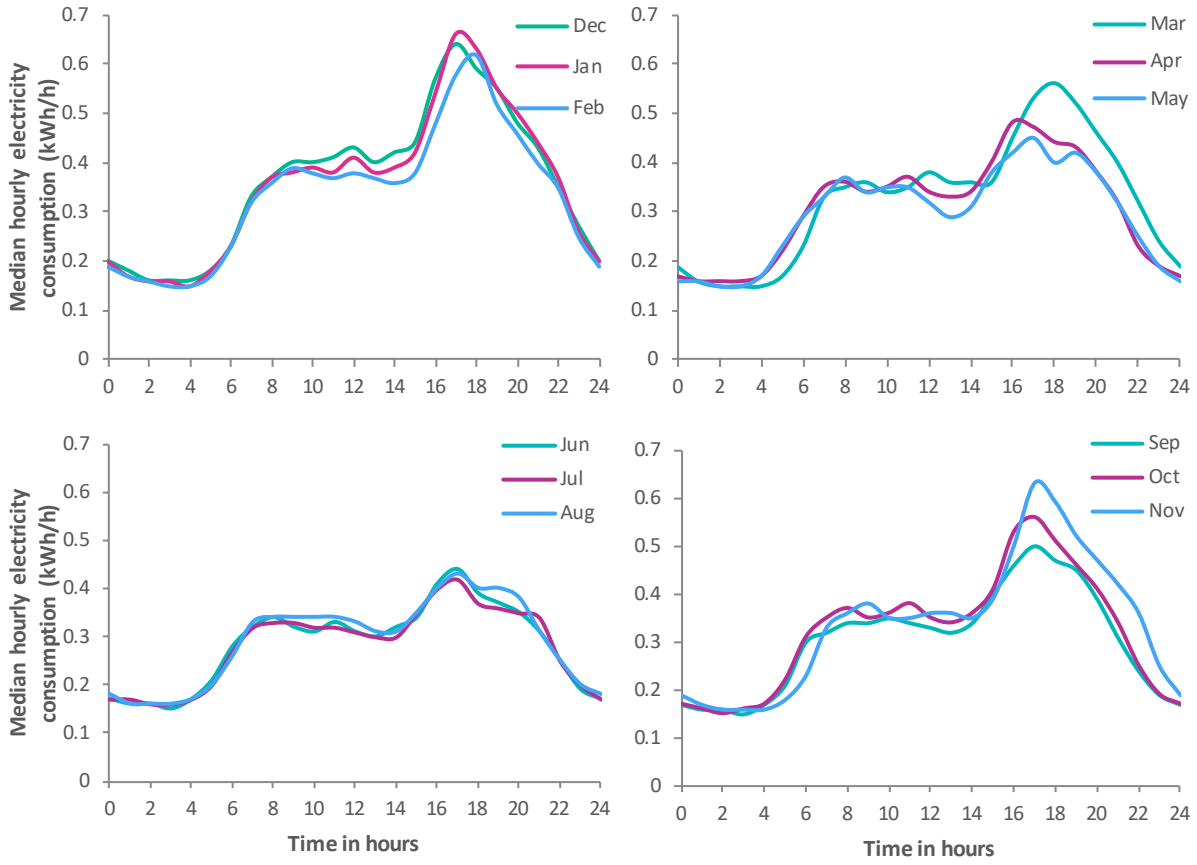
Figure 6.3: Median profile of mean hourly electricity consumption for the four seasons, 1st May 2018 to 30th April 2019



Base: all households with electricity consumption data for each season, main fuel not electric, (n=359- 392).

All seasons demonstrated the same general profile, with a morning increase between 05:00 and 08:00, a plateau through the late morning/early afternoon and then another increase in the late afternoon to a peak level of consumption around 17:00, before a steady decrease throughout the evening. The biggest difference between the median daily profiles for each season was the consumption over the evening peak. Although the peak was reached around the same time of day, the level of consumption varied across all seasons with winter being highest, as expected, and summer being lowest. The increase in consumption over the morning started slightly later in winter and had a higher value across the late morning and early afternoon, while the summer profiles showed a slight decrease in consumption over the same period. Both spring and autumn contained ‘shoulder months’ in which households move from winter to summer patterns; or vice versa, particularly in terms of heating. Analysing the daily profiles of the months within each season would show if this change in behaviour is also observed in electricity consumption in homes, where electricity is not the main heating fuel, as shown in Figure 6.4.

Figure 6.4: Median profile of mean hourly electricity consumption for the months within each season, 1st May 2018 to 30th April 2019



Base: all households with electricity consumption data for each month, main fuel not electric, (n=276- 386).

Figure 6.4 shows that the daily profiles were very similar within the winter and summer months, however, there was a gradual change between the profiles in spring and autumn, particularly for March and November. In March, the morning increase in consumption started later, in line with the winter months, however the evening peak in consumption, although higher than the other spring months, was not as high as the winter months, showing a gradual shift in behaviour throughout the spring months from winter electricity consumption to summer consumption.

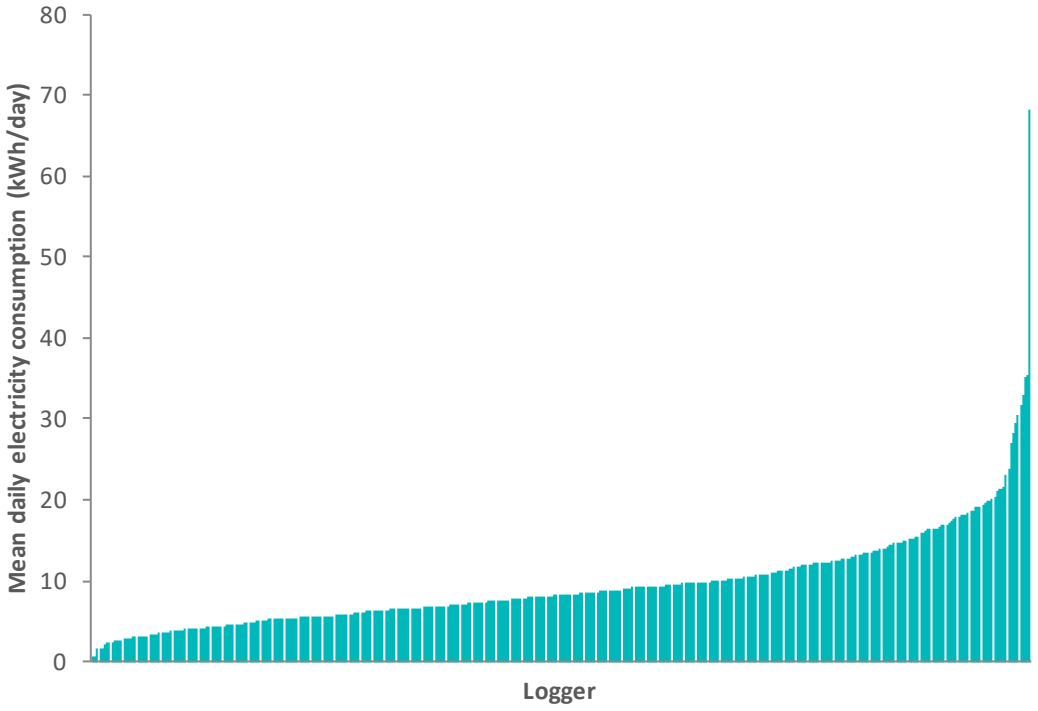
This shift throughout the season was clearer in the autumn where the consumption during the evening peak increased for each month from September to November. The daily profile for November also had a later morning increase in consumption compared with the other months in autumn, bringing it in line with the time the morning increase occurred during the winter months and suggesting the full transition into winter consumption patterns.

6.2 Variations in Domestic Electricity Consumption

The following section examines how median consumption profiles varied by household and dwelling characteristics. Figure 6.5 shows the average daily consumption for each site observed over the whole monitoring period; 1st May 2018 to 30th April 2019.

There was an extreme range between the highest and lowest daily averages, with the lowest recorded at 1 kWh and the highest reaching 68 kWh. The median and mean average daily electricity consumption over this period were 8.2 and 9.5 kWh respectively; the mean was slightly higher than the median, shifted by a small number of very high consuming households. When converted to annual consumption figures, the median and mean were 3,000 and 3,500 kWh respectively, in line with typical domestic consumption values reported by Ofgem[22]. Analysis in this report focuses on the median values so as not to be unduly influenced by these few extreme cases.

Figure 6.5: Mean daily electricity consumption for each household, 1st May 2018 to 30th April 2019



Base: all households (n=395) with electricity consumption data, main fuel not electric.

[22] https://www.ofgem.gov.uk/gas/retail-market/monitoring-data-and-statistics/typical-domestic-consumption-values (Electricity: Profile Class 1, Medium)

6.3 Variations in Electricity Consumption between Household Groups

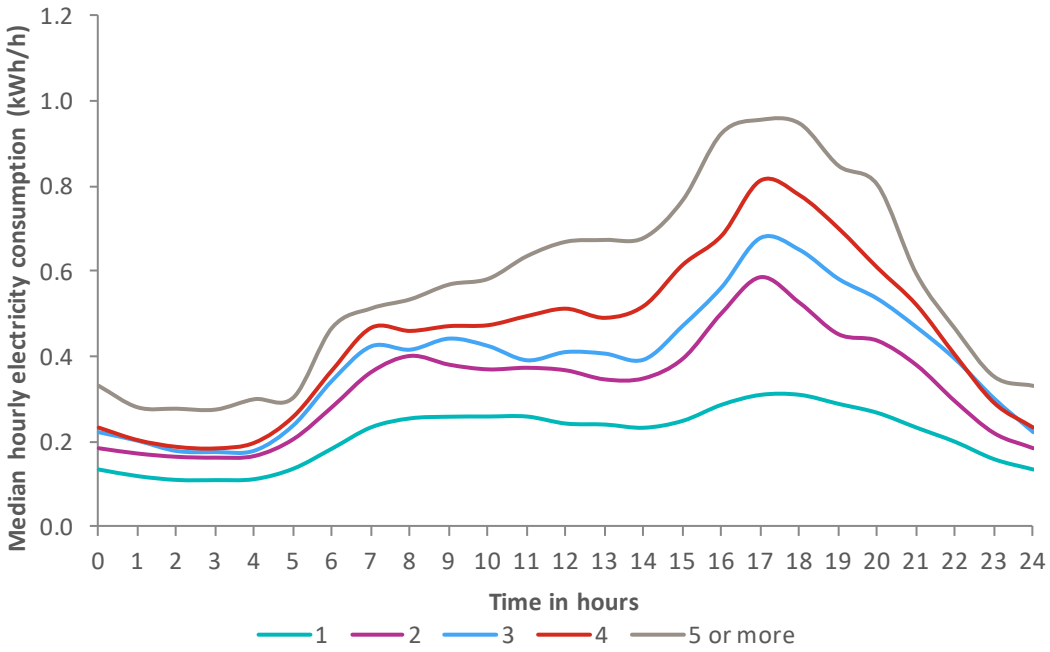
The following section will consider the impact of dwelling and household characteristics on electricity consumption by comparing median daily profiles between groups[23]. The characteristics analysed in the following section showed a significant difference between the average daily totals for each group within each characteristic. Splitting by household groups can lead to small sample sizes, therefore these results should be interpreted as indicative only. Notes have been included in the footnote of figures where individual group sample sizes drop below 30 cases.

6.3.1 Household Characteristics

The number and type of occupants both had an impact on the electricity consumption throughout the day. Figure 6.6 shows how the median daily profile of a household changed depending on the number of occupants. There was a direct relationship between number of occupants and the amount of electricity consumed; one-person households had the lowest level of electricity consumption throughout the day while households with five or more occupants had the highest. The difference is most prominent during the evening peak, with the peak level of consumption increasing, along with the duration of the evening peak, as the number of occupants in the household increased. Households with five or more occupants did not show a plateau in consumption over the late morning/early afternoon as seen in the other groups, instead their electricity consumption rose steadily across this time period.

[23] Dwelling and household characteristics reported at Interview 1 have been used for detailed consumption analysis

Figure 6.6: Median profile of mean hourly electricity consumption, 1st May 2018 to 30th April 2019, by number of occupants

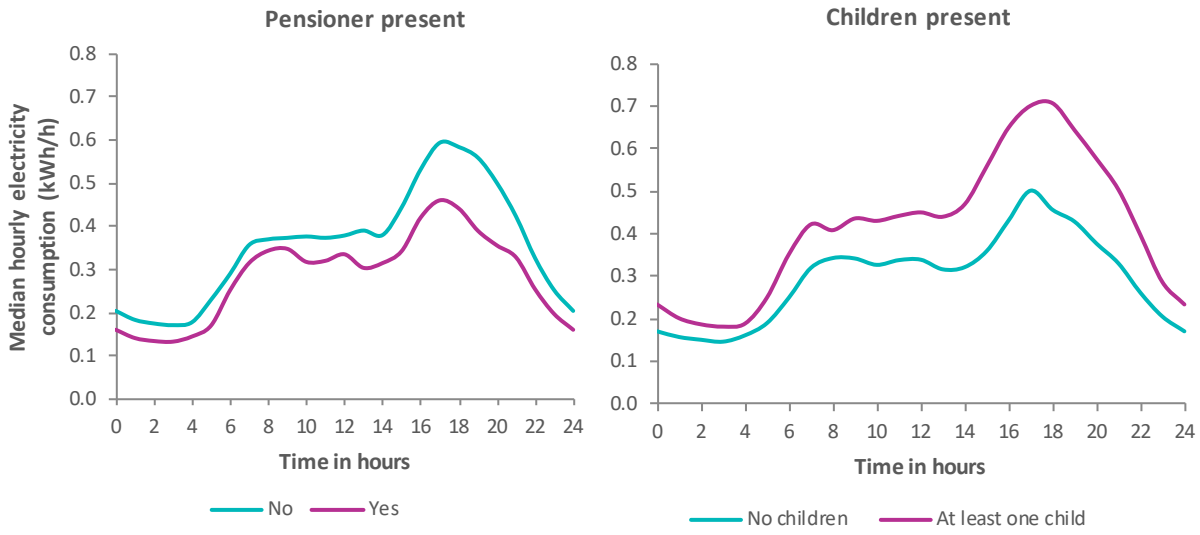


Base: all households (n=395) with electricity consumption data, main fuel not electric.

Note: 5 or more profile based on a small sample size (n=23), indicative only.

The composition of the household also affected the electricity consumption. Figure 6.7 shows how the median daily profile of households changed if a member of the household was over state pension age, and if at least one child was present. Although both characteristics had a significant effect on electricity consumption, the presence of a child had a greater effect. Households with at least one child present had a higher level of consumption throughout the day, particularly during the evening peak. The difference between the daily profiles of households with a member over state pension age (yes) compared with those without (no) was during the evening peak, with similar levels of consumption across the rest of the day.

Figure 6.7: Median profile of mean hourly electricity consumption, 1st May 2018 to 30th April 2019, by pensioner present and children present



Base: all households (n=395) with electricity consumption data, main fuel not electric.

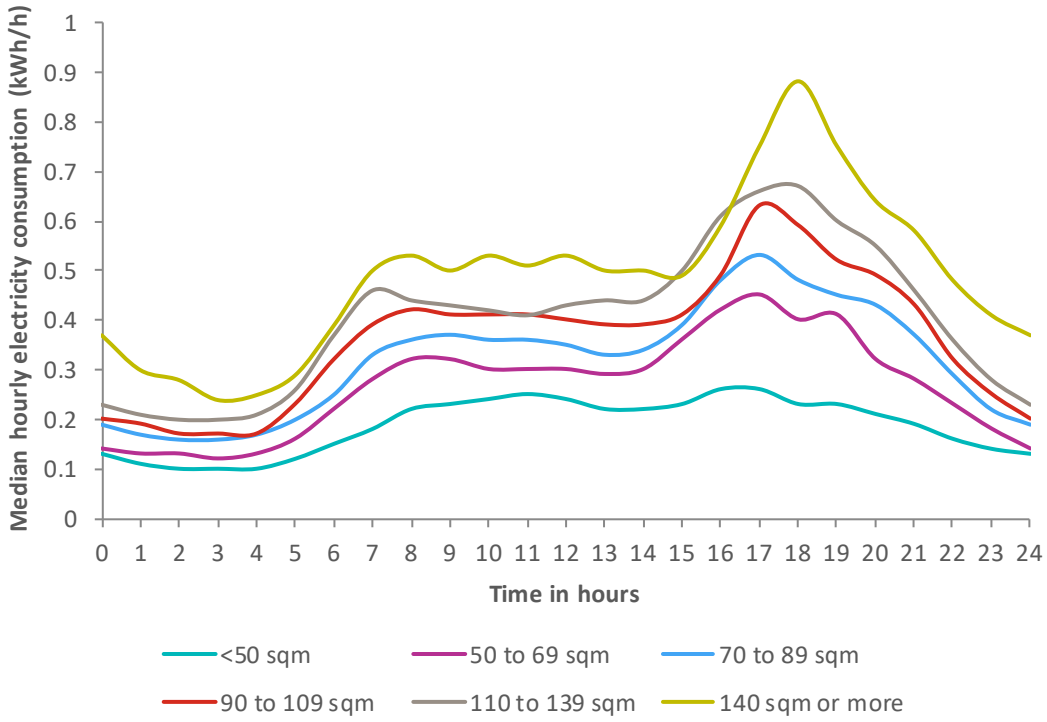
6.3.2 Dwelling Characteristics

When considering dwelling characteristics, a key driver of differences in electricity consumption between households was the floor area of the dwelling (Figure 6.8). As with number of occupants, there was a direct relationship between the floor area of the dwelling and electricity consumption; the smallest dwellings had the lowest level of electricity consumption, which then increased as floor area increased. Where all other households show the same trend throughout the day, those in the smallest dwellings, in terms of floor area, had a much flatter consumption profile. For this group of households, the morning increase in consumption occurred later in the day, increasing at a slower rate. There was also no evening peak, just a similar level of consumption from 08:00 to 18:00.

Another observation of note is the much higher level of consumption through the night among households in the largest dwellings. Larger dwellings are more likely to have more occupants, and these factors are likely to lead to increased appliance ownership, which could account for the higher electricity consumption.

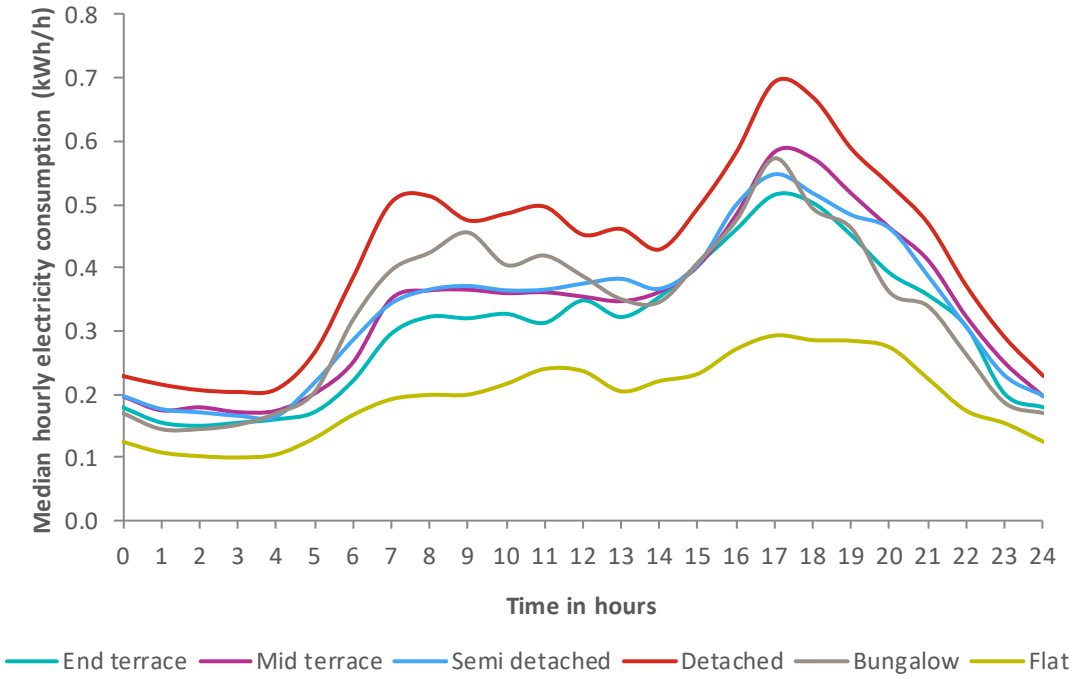
The type of dwelling also had a significant effect on electricity consumption (Figure 6.9). Although several groups had very similar profiles, detached properties had a much higher level of electricity consumption compared with all other dwelling types, while flats had a much lower level of consumption compared with other dwellings. Although most likely linked to floor area, it is interesting to compare the median daily profile of households living in flats with those living in houses and bungalows.

Figure 6.8: Median profile of hourly mean electricity consumption, 1st May 2018 to 30th April 2019, by household floor area



Base: all households (n=395) with electricity consumption data, main fuel not electric.

Figure 6.9: Median profile of hourly mean electricity consumption, 1st May 2018 to 30th April 2019, by household dwelling type



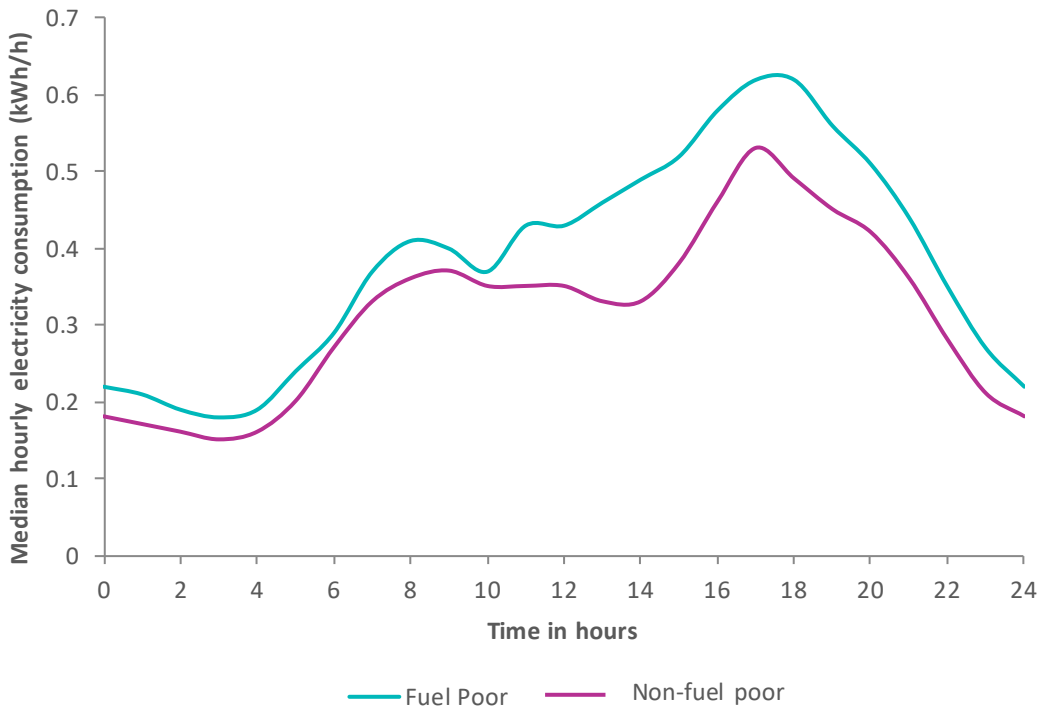
Base: all households (n=395) with electricity consumption data, main fuel not electric.

6.3.3 Fuel Poverty

Although the average daily consumption of fuel poor households was not significantly different to the average daily consumption of non-fuel poor households, the difference in their median daily profiles is of interest, as is shown in Figure 6.10.

The shape of the profile of fuel poor households was different to those not in fuel poverty, particularly over the late morning and afternoon. Firstly, the morning increase in electricity consumption peaked slightly higher for those in fuel poverty, although it decreased slightly between 09:00 and 10:00 before increasing throughout the rest of the afternoon, while the median profile of those not in fuel poverty remained at a consistent level of consumption. The steady rise in electricity consumption throughout the late morning and afternoon means there is no sharp rise to the evening peak as seen in the non-fuel poor households. However, the time of the evening peak was the same for both groups, 17:00, although the level of consumption at the peak was higher, and was maintained at that level for longer, in fuel poor households.

Figure 6.10: Median profile of hourly electricity consumption, 1st May 2018 to 30th April 2019, by fuel poverty status; non-fuel poor and fuel poor



Base: all households (n=395) with electricity consumption data, main fuel not electric.

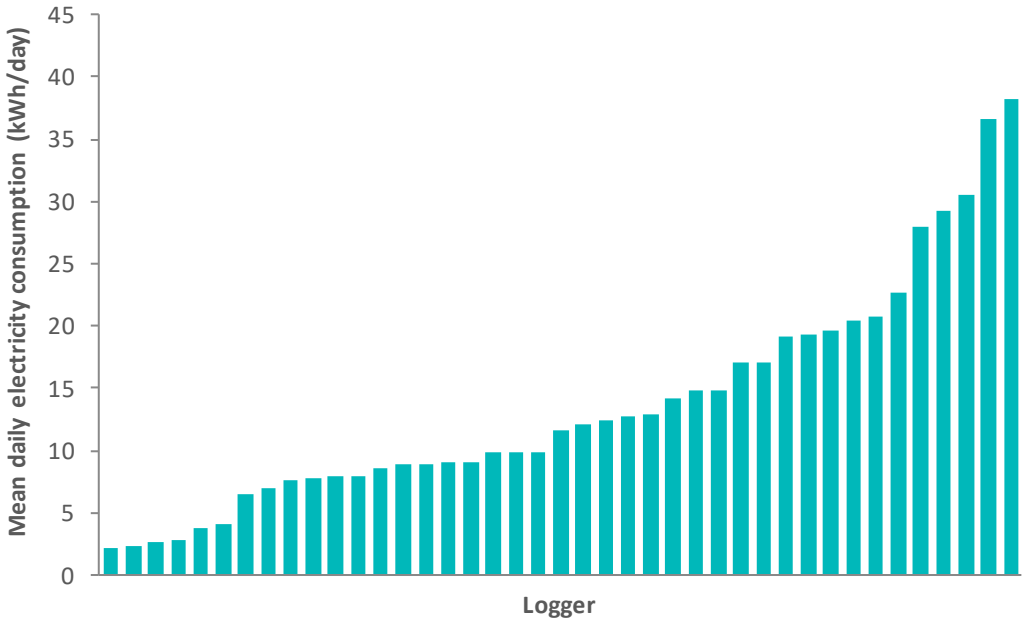
6.4 Households with Electric Main Heating Systems

All analyses on the electricity consumption data reported in previous sections have considered the sample without those with electricity as their main heating fuel. This section will analyse electricity consumption in households with electricity as their main heating fuel and make

comparisons with those that do not use electricity as their main heating fuel[24]. Due to small sample sizes, these results should be interpreted as indicative only. Notes have been included in the footnote for figures where sample sizes are below 30 cases.

Figure 6.11 shows the average daily consumption for households with electricity as their main heating fuel over the whole monitoring period; 1st May 2018 to 30th April 2019. Similar to households without electric heating, there was a large range between the highest and lowest daily averages, with the lowest reported at 2 kWh and the highest at 41 kWh. The median and mean over the consumption period were 11.7 and 13.7 kWh respectively, both higher than the averages for households where electricity was not their main heating fuel; where the median and mean were 8.2 and 9.5 kWh respectively.

Figure 6.11: Mean daily electricity consumption for each household with electricity as main heating fuel, 1st May 2018 to 30th April 2019



Base: all households (n=41) with electricity consumption data, main fuel is electric.

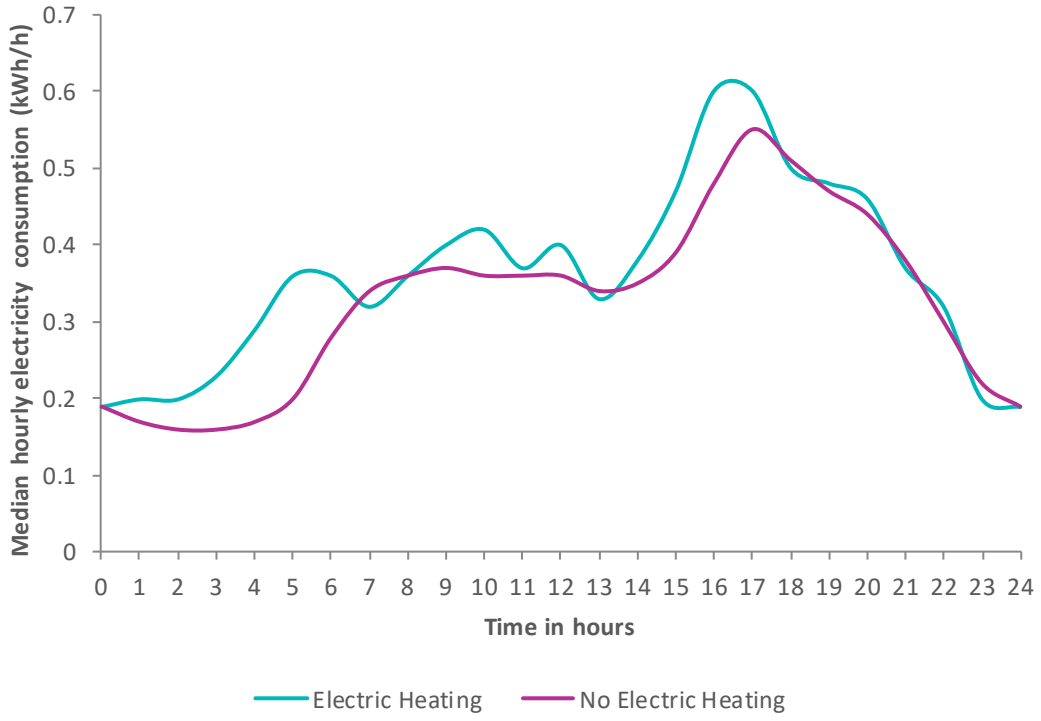
Looking at how consumption differed throughout the day between households with and without electricity as their main heating fuel, Figure 6.12 compares the median daily profiles of each group while Figure 6.13 shows the mean daily profile.

When considering the median daily profile, a similar trend is observed throughout the day for households with electricity as their main heating fuel compared with those without. However, the increase in consumption in the morning started two to three hours earlier and peaked two hours earlier. This is also true of the evening peak; the increase in the afternoon started an hour earlier and peaked an hour earlier. Peak consumption in the evening was higher in

[24] As reported at Interview 1

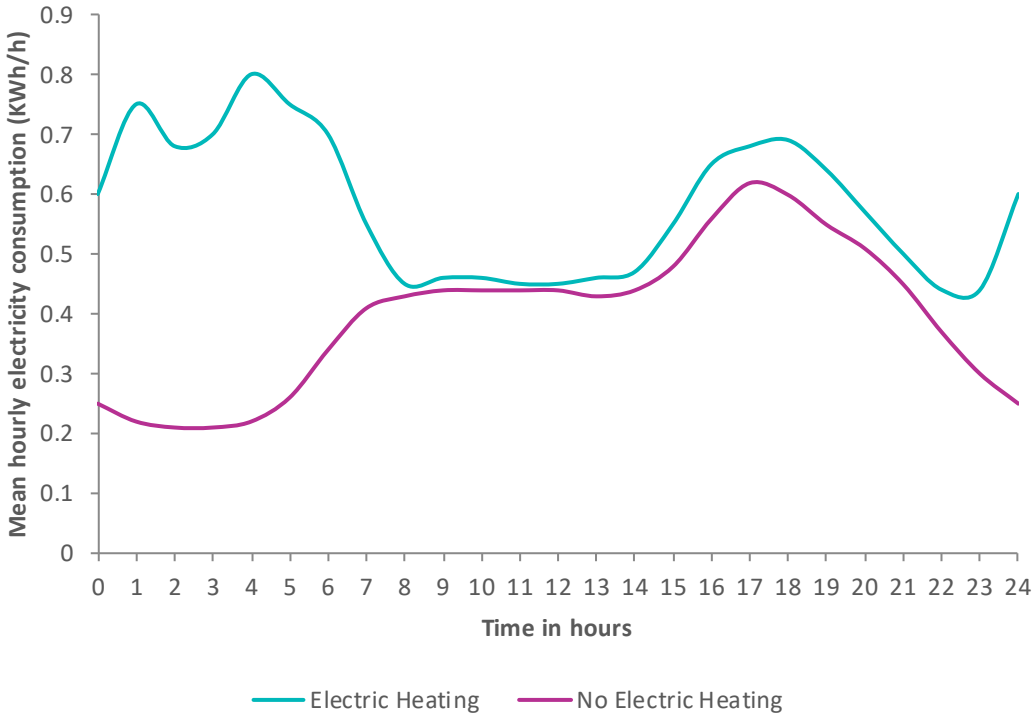
households with electricity as their main heating fuel, but consumption throughout the late morning/early afternoon was at a similar level to those without.

Figure 6.12: Median profile of mean hourly electricity consumption, 1st May 2018 to 30th April 2019, by households use of electric heating



Base: all households with electricity consumption data, main fuel is electric (n=41), main fuel not electric (n=395).

Figure 6.13: Mean profile of mean hourly electricity consumption, 1st May 2018 to 30th April 2019, by households use of electric heating

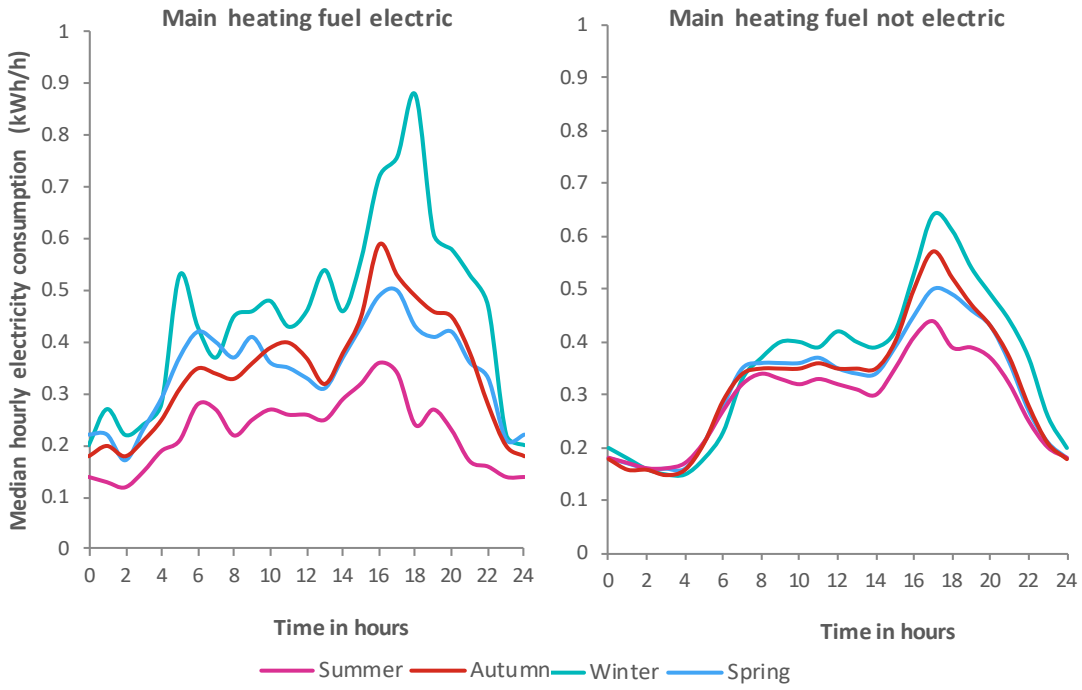


Base: all households with electricity consumption data, main fuel is electric (n=41), main fuel not electric (n=395).

The shape of the mean daily profile is very different when comparing households with electricity as their main heating fuel and those without. For households with electricity as their main heating fuel, the highest level of consumption was during the night/early hours of the morning, with the increase in consumption beginning around 23:00, reaching a peak at 01:00 before decreasing slightly and reaching another peak around 04:00. After 08:00 the mean profile of those with electricity as their main heating fuel matches those without. The high consumption over the evening/early morning is likely caused by households with storage heaters, whose high use during this time would skew the mean but not affect the median. This contrast between the mean and median profiles is analysed further in Appendix B, by considering the distribution of electricity consumption between households at four times throughout the day. The difference between the median and mean daily profiles indicates that households with electricity as their main heating fuel will have different consumption profiles throughout the day depending on their heating system; storage heaters, electric heaters or heat pumps. Due to small sample sizes, analysis of these households based on their heating system was not possible, however it is something to consider through the rest of the analysis of these households. All further analysis in this section has been performed using median daily profiles. Additional mean daily profiles, that show how mean consumption changes for different seasons and months, are presented in Appendix C.

Figure 6.14 shows the median daily profile for each season for households with electricity as their main heating fuel, along with the median daily profile for each season for households without.

Figure 6.14: Median profile of mean hourly electricity consumption of households for the four seasons, 1st May 2018 to 30th April 2019, with and without electricity as their main heating fuel

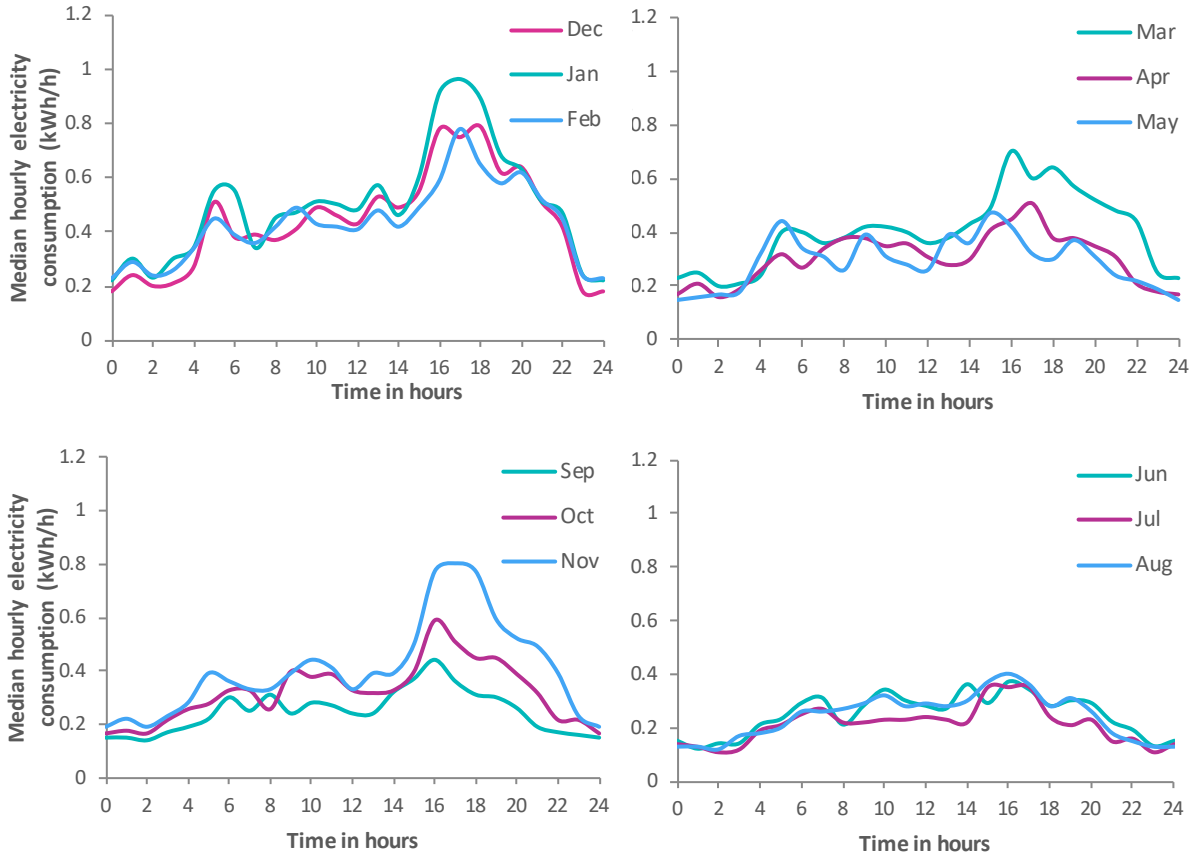


Base: all households with electricity consumption data for each season, main fuel is electric (n=38-41), main fuel not electric (n=359-392).

Most marked in the comparison of these daily profiles is the high level of consumption over winter for households with electricity as their main heating fuel, both compared with the other seasons, and compared with winter consumption of those that use gas and other fuels for heating. Although the daily profiles for spring and autumn consumption were at a similar level between households with and without electric heating, summer consumption was much lower in households with electricity as their main heating fuel. This is presumably caused by these households being more likely to live in flats, which tend to have lower levels of consumption than other dwelling types (Figure 6.9). The profiles also show that in the 'shoulder' seasons, electrically heated homes had different patterns of consumption in spring compared with autumn. In spring, morning electricity consumption was higher than in the autumn, suggesting that households were still heating their homes in the morning, but in the evening the profiles are more similar. In autumn, the opposite is true; morning use was lower (though still higher than summer) but it appears that some evening heating was required.

Figure 6.15 shows how the median daily profiles changed between the months within each season for households with electricity as their main heating fuel.

Figure 6.15: Median profile of mean hourly electricity consumption of households for each month within each season, 1st May 2018 to 30th April 2019, with electricity as their main heating fuel



Base: all households with electricity consumption data for each month, main fuel is electric, (n=26-41).

Note: May and June profiles based on small sample sizes (n=26 May, n=29 June), indicative only.

As with households without electricity as their main heating fuel, the daily profiles within the summer and winter months were similar, although January showed a much higher level of consumption in the evening peak. For the spring and autumn months however, particularly in autumn, there was a shift from the summer pattern of consumption to the winter one. Consumption in September increased slightly in the evening compared with the summer months, while in October, consumption levels throughout the day increase and then in November the evening peak increased substantially, in line with the evening peaks of December and February. In spring, the median daily profiles of April and May were similar, however March had a higher level of consumption throughout the evening, although not as high as the winter months, showing a transition from winter levels of consumption to summer levels.

The electricity consumption profiles shown in Figure 6.15 use electricity consumption collected over a single year and therefore the results need to be considered in reference to the monthly variations in temperature for that year and how they differ from average monthly temperature variations. Figure 6.16 shows the average monthly temperature for each month over the monitoring period and the average monthly temperature recorded between 1981 and 2010 for comparison. The temperatures throughout the summer, winter and spring of the monitoring period were higher than the monthly averages, while the temperatures throughout autumn were similar to the monthly averages.

Figure 6.16: Met Office England monthly average external temperatures, 1st May 2018 to 30th April 2019

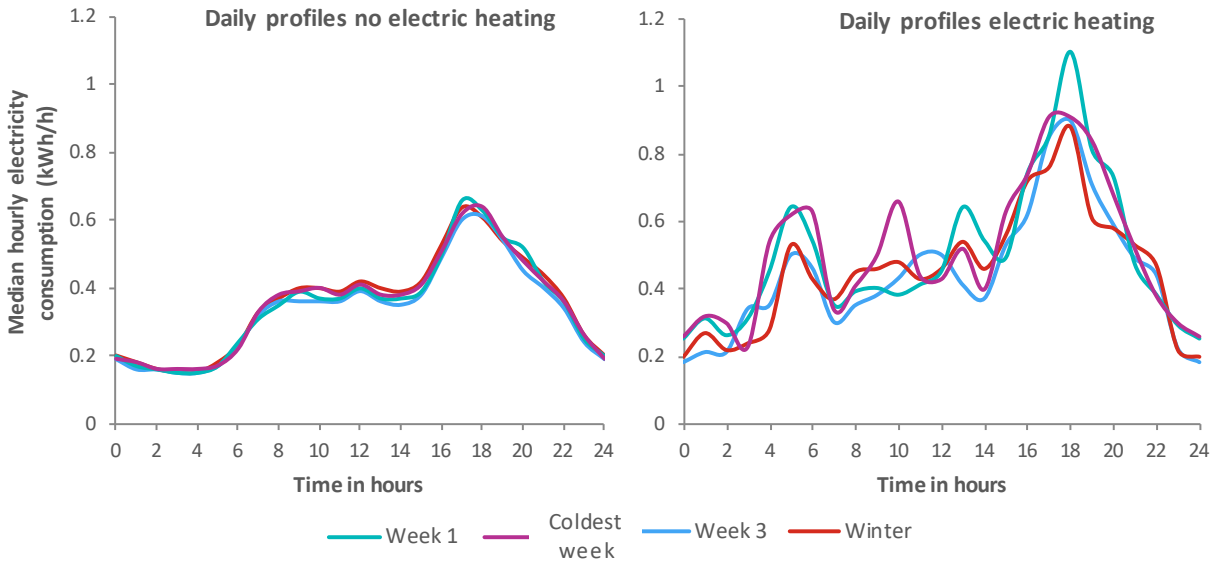
Source: Met Office England Mean Temperature Areal Series (accessed 02/01/2020).

6.5 Electricity Consumption during the Coldest Week

Although households' typical habits in terms of electricity consumption are interesting, it is also worth investigating where these habits might change. An example of this is to consider a particularly cold week and compare electricity consumption during this week to weeks either side. The coldest week during the monitoring period (May 2018 to April 2019) was the week commencing 28th January 2019 (Week 2) when external temperatures averaged 0.9°C. The daily consumption profile averaged over the coldest week were compared to the daily consumption profiles of the weeks either side, commencing 21st January 2019 (Week 1) and 4th February 2019 (Week 3) respectively. Analysis of gas consumption over this time period is included in the 'Household Energy Consumption and Affordability' report.

Figure 6.17 shows the median daily profile of each week; coldest week (Week 2) and the weeks before and after (Week 1 and Week 3 respectively) for households where electricity was not their main heating fuel, along with the median daily profiles of each week for households where electricity was their main heating fuel. In both cases the median daily profile for winter has been included for comparison. Mean daily profiles for each of these three weeks can be found in Appendix C.

Figure 6.17: Median profile of mean hourly electricity consumption of households, 21st January 2019 to 10th February 2019, by main heating type



Base: all households with electricity consumption data for the coldest period over the monitored year and winter, main fuel is electric (n=39/n=39), main fuel not electric (n=379/n=387).

The electricity consumption of households with no electric heating was minimally affected by the change in temperatures over the three week period, however, the median profiles of those with electricity as their main heating fuel were[25]. During Week 1, the peak in consumption over the three week period occurred around 17:00, but in addition, when comparing with the typical winter profile, there was a higher level of consumption during the morning; the peak at 05:00 was higher in Week 1 compared with the median winter profile.

During Week 2 (the coldest week), the higher level of consumption around 05:00 was still present, and although at a similar level to Week 1, the higher level of consumption occurred for longer; from 04:00 to 06:00. In addition to this, there was a further peak in consumption at 10:00 during Week 2, which did not occur in either of the other two weeks or in the median daily profile for winter. Although the evening consumption during Week 2 was at a lower level compared with Week 1, the peak in consumption was much wider than the median winter

[25] The sample size of household with electric heating is small therefore these results should be interpreted as indicative only

profile, suggesting electricity was being used for longer over the evening during Week 2 compared with a typical winter week.

During Week 3, the profile followed most closely to the median daily profile of a typical winter week, suggesting that returning to typical winter habits, in terms of electricity consumption, occurred quite quickly after this cold spell.

6.6 Comparison with EFUS 2011 Electricity Consumption Data

As part of the EFUS 2011, electricity was monitored at 10 second intervals in 79 homes in order to investigate the demand from lights, appliances and cooking. To analyse electricity consumption from lights, appliances and cooking exclusively, households were excluded from electricity monitoring if they had any use of electric space (main or supplementary) and/or water heating. For the analysis of the 2017 electricity consumption data households with electricity as their main heating fuel have also been excluded, although there are still households with electric supplementary heating or electric water heating. Despite this, it is still of interest to observe any changes in the extent of electricity consumption between EFUS 2011 and 2017.

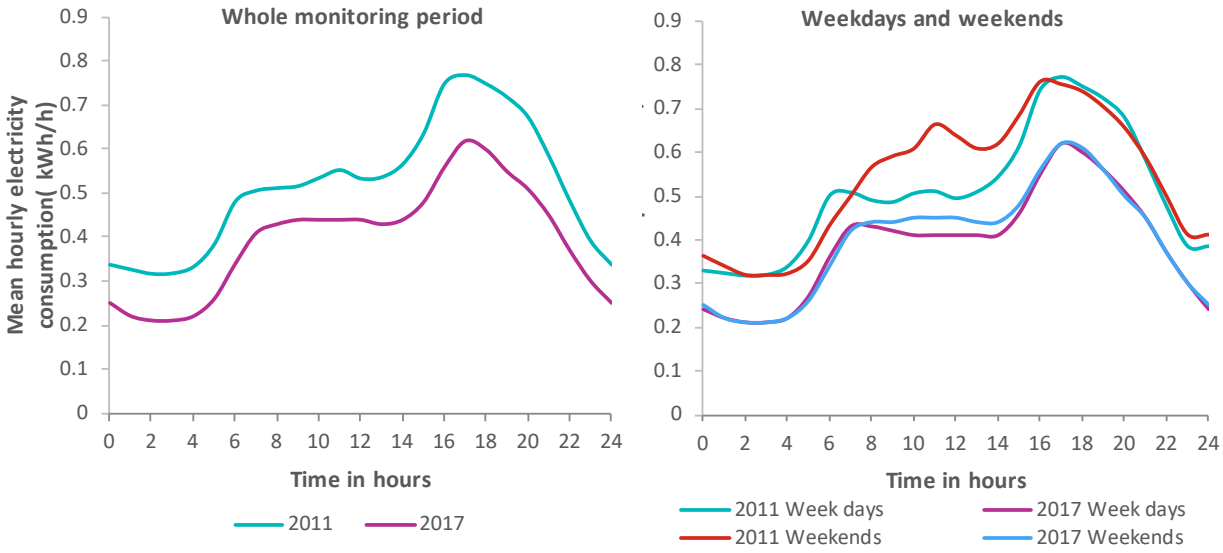
The median and mean annual consumption was estimated to be 3,900 and 4,600 kWh respectively in 2011 compared with the estimated median and mean annual consumption in 2017; 3,000 and 3,500 kWh respectively. Therefore, despite the inclusion of households that could have additional loads on their electricity, in the form of electric water heating and supplementary electric heating, the estimated annual electricity consumption has decreased since the 2011 survey.

A lower level of consumption in 2017 is also observed when comparing daily profiles between 2011 and 2017. In 2011 the mean hourly demand was used when reporting daily profiles, and therefore the mean hourly demand was also established for the 2017 data (median hourly demand has been reported in all previous sections). Figure 6.18 shows the mean daily profile averaged over the whole monitoring period for each year and the daily profiles for weekdays and weekends.

The electricity consumption was higher throughout the day in 2011, however a similar shape is seen, with an increase in the morning, a plateau through the late morning/early afternoon before a second increase in the afternoon leading to peak consumption around 17:00. When comparing the weekday and weekend profiles, the 2017 data showed little difference between the weekday and weekend daily profiles, while the 2011 weekday and weekend profiles were different. Firstly, the delay in the start of the morning peak on weekend days was more prominent, with the increase in consumption continuing throughout the morning, compared with consumption plateauing on weekday days, to a peak around 11:00. The morning peak was followed by a slight decrease before increasing again to the evening peak, where the level of consumption was very similar between weekday and weekend days. In addition to comparing weekday and weekend daily profiles, the daily profiles for different months of the year, where

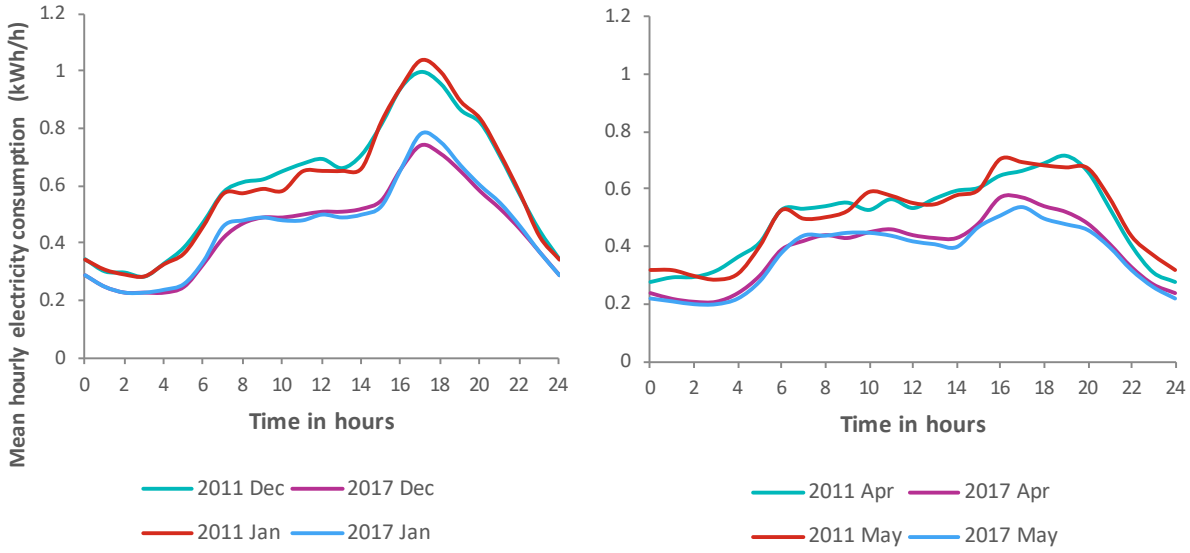
these were monitored in 2011, have also been compared and are shown in Figure 6.19 and Figure 6.20. As with the profiles in Figure 6.18 these are mean hourly profiles.

Figure 6.18: Mean profile of mean hourly electricity consumption by whole monitoring period and for weekdays and weekends, 2011 and 2017



Base: all households (n=395) with electricity consumption data for 2017 (1st May 2018 to 30th April 2019), main fuel not electric, all households (n=79) with electricity consumption data in 2011 (May 2011 to January 2012).

Figure 6.19: Mean profile of mean hourly electricity consumption for December, January, April and May, 2011 and 2017

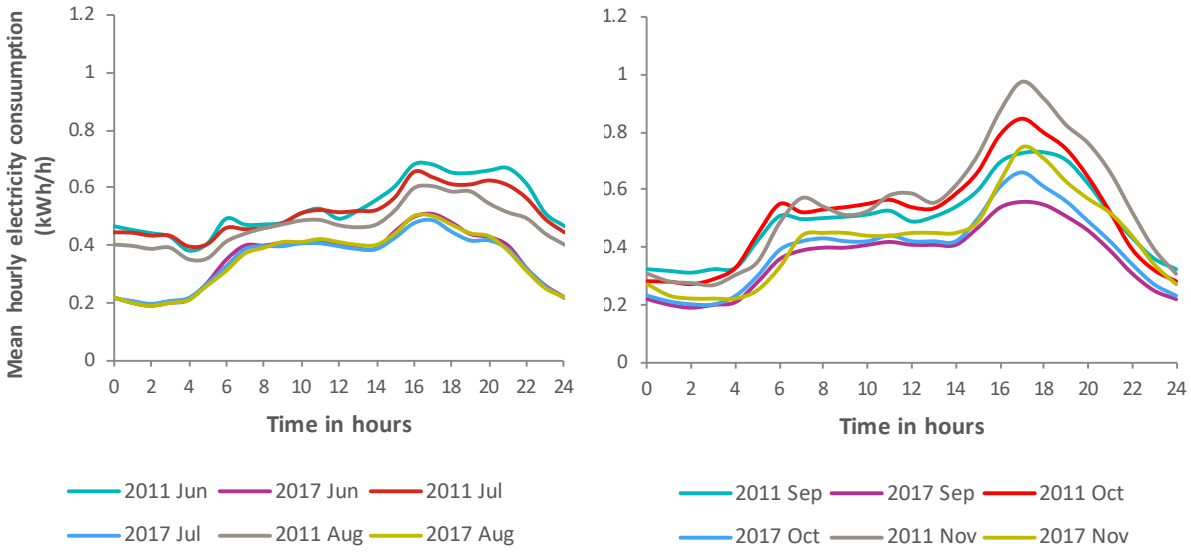


Base: all households with electricity consumption data for each month in 2017 (n=276-386), main fuel not electric, all households with electricity consumption data for each month in 2011 (n=25-78).

Note: April profile based on small sample sizes (n=25), indicative only.

As seen in Figure 6.19 and Figure 6.20, the level of electricity consumption in the 2011 daily profiles was higher than those of 2017 across all months. Interestingly, the trends throughout the day for each month were similar between the two years. There was a more pronounced transition throughout the autumn in 2011, however the same increase in peak evening usage and shift to the morning increase beginning later was observed in both years. A noticeable difference is the high use throughout the night that was observed in the 2011 summer months, meaning there wasn't a prominent increase in the morning compared with 2017.

Figure 6.20: Mean profile of mean hourly electricity consumption for June through to November, 2011 and 2017



Base: all households with electricity consumption data for each month in 2017 (n=276-386), main fuel not electric, all households with electricity consumption data for each month in 2011 (n=64-78).

7. Conclusions

The three EFUS 2017 interview surveys, combined with information gained from the previous 1998 and 2011 EFUS, have provided us with valuable information regarding trends in the ownership and use of lighting, common domestic appliances and current ownership of smart technologies. Combining the interview data with detailed electricity consumption data has allowed insight into how household characteristics and appliance ownership can impact electricity consumption throughout the day.

Lighting

Analysis has been carried out on the types of lightbulbs owned by households in each of the four main rooms in the house; kitchen, living room, main bedroom and hallway/landing. Householders were also asked about lighting use and analysis on the difference between weekday and weekend lighting use has been presented, for both winter and summer.

The main conclusions from ownership and use analysis can be summarised as:

Ownership

- Low energy LED and fluorescent strip were the prevalent lightbulb type used in the kitchen, with 35% of householders having at least one LED lightbulb in their kitchen while 33% owned at least one fluorescent strip lightbulb.
- Low energy CFL were the prevalent lightbulb type in the other main rooms; living room, main bedroom and hallway/landing, with 44% of households reporting at least one CFL lightbulb in their living room, 45% owning at least one in their main bedroom and 44% owning at least one in their hallway/landing.
- Owner occupiers, households with two or four occupants and households with at least one person in employment were more likely to own low energy LED lightbulbs compared with their respective groups.
- Households with at least one member over state pension age and households with no-one in employment were more likely to own tungsten filament lightbulbs compared with their respective groups.
- Timeseries analysis suggests there has been a decrease in ownership of tungsten filament and fluorescent strip lightbulbs since the 1998 EFUS, with the decrease in ownership of these types of lightbulb also significant when comparing ownership between the 2011 and 2017 EFUS.

Use

- Of the four main rooms in the house, the living room had the highest median number of lighting hours in both summer; two hours compared with one in the kitchen, bedroom and hallway/landing, and winter; six hours compared with three in the kitchen and one in the bedroom and hallway/landing.
- Analysis between weekday and weekend day lighting use suggests that the majority of households did not change their lighting habits, and where there was a change, more lighting was used at the weekend. This was true of both summer and winter lighting use.

Appliances

Appliance ownership and use, as reported by households, has been analysed by socio-economic characteristics and compared with reported ownership in the 2011 and 1998 EFUS where appropriate. The main conclusions from ownership and use analysis can be summarised as:

Ownership

- Considering laundry appliances, 97% of households owned a washing machine while only 58% owned a tumble dryer[26]. Households with more than two occupants, owner occupiers, households with at least one person in employment and those with an income in the fifth quintile were more likely to own a tumble dryer compared with the other categories in their relative groups.
- The majority of households owned a fridge and owned a freezer; 99% and 93% respectively. Households with two or more occupants and those with at least one child present were more likely to own a freezer compared with the other categories in their relative groups. Cold appliances had a considerable impact on the electricity consumption of a household, with consumption throughout the day increasing as the number of cold appliances the household owned increased.
- Ownership of dishwashers has increased steadily; 21% in 1998, 38% in 2011 and 44% in 2017. Households with more than one occupant, those in the fifth income quintile and under occupiers were more likely to own dishwashers compared with the other categories in their relative groups.
- Ownership of ovens, hobs and microwaves was high among households; 96%, 92% and 90% respectively, whereas reported ownership of grills was much lower; 65%, and only 3% of households reported owning a range style cooker. Ownership of microwaves has increased between the three EFUS from 74% in 1998, 80% in 2011 and 90% in 2017.

[26] Both washing machine and tumble dryer ownership categories include combined washer dryers.

- The most common cooking appliance combination was electric oven and electric hob (37%) followed by electric oven and gas hob (33%). Households with no-one in employment and one person households were more likely to own the electric oven and electric hob combination compared with the other categories in their relative groups. The electric oven and gas hob combination was more likely to be owned by owner occupiers, compared with private renters, and households with at least one person in employment.
- When reporting ownership of electrical entertainment appliances, the majority (96%) of households owned a TV (or digital TV box) and a mobile phone (94%) while ownership of other entertainment appliances (games consoles, laptops, tablets and internet connected speakers) was lower. Composition of a household affects ownership of electrical entertainment devices, with households with at least one child present more likely to own games consoles, laptops, mobile phones, tablets and internet connected speakers compared with households without children present. Households without a member over state pension age were also more likely to own games consoles, laptops, mobile phones, tablets and internet connected speakers compared with those with. In addition, households with at least one person in employment were more likely to own games consoles, laptops, mobile phones, tablets and internet connected speakers compared with households without.
- Ownership of energy intensive electrical appliances, such as aquariums, heated swimming pools and heated hot tubs, was low, with only 10% of households owning at least one. Households with five or more occupants were more likely to own one of these appliances compared with those with one to three occupants. Households with at least one child present were more likely to own one compared with households without. The electricity consumption of households who owned at least one of these devices was much greater throughout the day compared with households that did not.
- The most commonly owned electrical cooling appliance was a portable fan, with 50% of households reporting ownership. There was a significant increase in the ownership of electrical cooling devices since the 2011 EFUS.

Use

- When analysing laundry appliance use, the number of washing loads increased with the size of the household, with the median number of loads increasing from two to seven as household size increased from one to five or more occupants. The number of loads dried also increased with household size. The median number of loads dried increased from two to six as household size increased from one to five or more occupants.
- Electricity was the most dominant fuel used for oven and grills; 73% and 48% respectively, while gas was the dominant fuel used for hobs; 54%. The use of electricity as the dominant cooking fuel has increased between the three EFUS; 1998, 2011 and 2017.

Smart Technology

Questions on ownership and use of smart technologies were asked for the first time during EFUS 2017. Householders were asked to report on ownership of smart lighting devices, smart appliances, smart meters and smart heating controls. Follow up questions on the impact of these devices on lighting use and energy use have also been reported on.

The main conclusions can be summarised as:

- Ownership of smart lighting devices was low across households, with only 3% of households owning at least one of; smart lamp, smart bulbs and smart lighting controls, at Interview 1. Where smart bulbs were owned, most households had them in their living room. When asked if ownership of a smart lighting device had affected the length of time they used their lighting, 64% reported no change in lighting use. At interview 3, 7% of households reported owning at least one smart lighting device, a significant increase from Interview 1.
- The most commonly owned smart appliances were internet connected digital TV boxes (81%) and internet connected smart TVs (55%). Households with at least one person in employment and without a member over state pension age were more likely to own a smart appliance compared with households without anyone in employment and households with a member over state pension age, respectively.
- Ownership of smart meters, either electricity or gas, was reported at 27% at Interview 1, increasing to 36% at Interview 3. Of those owning a smart meter, 78% reported owning an energy display. When asked if ownership of a smart display had an impact on energy use, most households (68%) reported using the same amount of energy, whereas 24% reported using less.
- Ownership of smart heating controls was low, with 8% of households reporting ownership of one at Interview 2, and 9% at Interview 3. When asked about the impact on heating use, households most commonly reported that they used their heating a little less (31%) or the same amount (26%).
- Only 4% of households reported owning PV, and of these, 54% reported changing the time they ran their appliance to coincide with when the PV panels were generating electricity.

Electricity Consumption

Detailed electricity consumption data was collected between 1st May 2018 and 30th April 2019 in 436 households. Data was collated into hourly averages from which median daily profiles were plotted to analyse how electricity consumption changes throughout the day, and how this differs between different times of the year and between household characteristics.

- The median electricity consumption profile of all households across the whole monitoring period showed a rapid rise in consumption over the morning, peaking

between 07:00 and 08:00. Consumption then plateaued throughout the morning and early afternoon before increasing again to reach a peak in consumption at 17:00. Consumption then decreased steadily throughout the evening.

- There was little difference between the median daily profiles of weekdays and weekend days.
- When comparing the median daily profiles for each season; winter, spring, summer and autumn, electricity consumption was lowest in summer and highest in winter, with the main noticeable difference occurring during the evening peak. Daily consumption profiles within seasons were similar, although differences were evident for the 'shoulder months'; March had a higher consumption in the evening compared with April and May, whereas consumption in the evening steadily increased from September to November.
- When comparing daily consumption profiles between household characteristics, the number of occupants had a prominent impact, with higher median electricity consumption observed throughout the day as the number of occupants increased. Household composition also had an impact, with households with at least one child present having higher median electricity consumption throughout the day compared with households without children.
- When considering dwelling characteristics, dwelling floor area has a direct impact on electricity consumption; with a higher median electricity consumption across the day, particularly in the evening peak, as the floor area of the dwelling increased. A subsequent observation from this was that flats had a lower median electricity consumption across the day compared with any other dwelling types.
- The median average daily consumption was higher in households that used electricity as their main heating fuel; 11.7 kWh for electrically heated dwellings compared with 8.2 kWh for non-electrically heated dwellings. There was a large difference in the winter daily profiles of households that used electricity as their main heating fuel compared with those that did not. Other seasons had a similar level of consumption.
- Electricity consumption data was also collected as part of the EFUS 2011 survey. The estimated median annual consumption calculated from the 2017 data was lower; 3,000 kWh in 2017 compared with 3,900 kWh in 2011. When comparing daily profiles, median electricity consumption was higher throughout the day in 2011, compared with 2017, although the shape of the profiles were similar, particularly across different months of the year.

Glossary

Term	Description
Age of dwelling:	This is the date of construction of the oldest part of the dwelling. Recorded by surveyors in the EHS physical survey.
Age of HRP:	The Household Reference Person (HRP) is the person in whose name the dwelling is owned or rented or who is otherwise responsible for the accommodation. In the case of joint owners and tenants, the person with the highest income is taken as the HRP. Where incomes are equal, the older is taken as the HRP. This procedure increases the likelihood that the HRP better characterises the household's social and economic position. The age of the HRP is derived from: variables obtained from the EHS Interview survey for households that had not changed since the earlier EHS interview. householder responses to questions 45-50 in EFUS Interview 1 and questions 41-45 in EFUS Interview 3 for new households.
Alternative heating:	Heating system present in a room (or rooms) used as an alternative to the main heating system.
After housing costs equivalised income – weighted quintiles:	This is calculated based on the fuel poverty income (from 2015 & 2016 fuel poverty datasets) and updated to account for any changes to income at Interview 1 and Interview 3 EFUS questionnaires. Validation of income based on reasons why household income had changed for the Interview 3 questionnaire provided increased confidence and reliability of the income.
Boiler type:	Derived from the EHS data.
Children Present:	Anyone in the household who is 16 years old or younger at the time of the EFUS interview. This is derived from; variables obtained from the EHS Interview survey for households that had not changed since the earlier EHS interview. householder responses to questions 45-50 in Interview 1 and questions 41-45 in Interview 3 in the EFUS questionnaires for new households
Daytime Occupancy	Derived from the EFUS survey. A household has been classified as being 'in during a weekday' if they indicated being generally in the house on weekdays during the winter, for both the morning and afternoon periods. A household is classified as 'not in during the day' if they responded as not being in for both the

Term	Description
	morning and the afternoon periods. Households who were in for either the morning or afternoon period were coded as 'Variable' occupancy.
Dwelling insulation:	The number of insulation measures (0 to 3) where positive responses for 'fully double glazed', 'insulated walls' and having loft insulation greater than 200mm count as insulation measures. EFUS Interview 1 and interview 3 questionnaires asked respondents about new insulation measures installed since the EHS survey. New windows installed since the EHS survey are excluded from the analysis as it cannot be assumed that this resulted in the dwelling being fully double glazed.
Dwelling type:	Classification of dwelling on the basis of the surveyors' inspections during the EHS physical survey.
Employment status of the household:	Derived from W1_q56 of EFUS Interview 1, and the modelling assumes responses are for all adults in the household (HRP, partner and any other additional adults in employment). 'Don't know' responses were coded as having no employment. Households either have at least one person employed, or all adults are unemployed.
Energy Performance Certificate (EPC) band:	Energy Performance Certificate band, also sometimes known as the Energy efficiency rating (EER) band (SAP 2012) of the dwelling. Bands from A to G that are used in the Energy Performance Certificate. 'A' is the most efficient and 'G' is the least efficient. Derived from the SAP 2012 methodology used for the 2016 EHS. SAP2012 was re-modelled for dwellings which have had improvements between the EHS and EFUS Interviews 1 and 3.
Fuel poverty (LIHC) status:	Based on the 'Low Income High Cost' (LIHC) definition, a household is considered to be fuel poor if: they have required fuel costs that are above average (the national median level); were they to spend that amount, they would be left with a residual income below the official poverty line. Each household's fuel poverty status has been updated using EFUS data on household changes, incomes and modelled fuel costs due to dwelling improvements.
Fuel poverty gap:	The difference in pounds between the required energy costs for each fuel poor household and the nearest fuel poverty threshold.
Fuel type of main heating system:	As recorded by surveyors in the EHS physical survey. Grouped into 'mains gas', 'electricity' and 'other', which includes bottled gas, bulk gas, solid fuels, oil and community schemes. The data

Term	Description
	was updated at Interview 2 and Interview 3 if a household reported using a different main heating system. Assumptions for households reporting having central heating but did not answer about fuel type: - Set to mains gas if a mains gas connection was recorded in the EHS - If not on mains gas set to EHS recorded main fuel - If reported not on gas in EFUS Interview 1, then categorised as 'other' gas (e.g. bottled).
Fully double glazed:	Derived from the 'dblglaz4' EHS variable as recorded by surveyors in the physical survey. Fully double glazed is defined as 'entire house double glazed'. Not fully double glazed is anything less than fully double glazed. New windows installed since the EHS survey were excluded from the analysis as it could not be assumed that this resulted in the dwelling being fully doubled glazed.
Heating season:	The months when there is a requirement for the main heating system to provide heat. For the EFUS 2017 survey this is calculated based on householder responses to a question in Interview 2 (what month heating began every day) and a question in Interview 3 (what month heating stopped every day), both asked in relation to Winter 2017/18.
Household size:	Number of persons in the household, banded into 5 groups, derived from the 'hhsizex' variable from the EHS Interview survey. The data was updated following any changes to household composition recorded in EFUS Interview 1 and Interview 3 questionnaires.
Insulated walls:	Derived from the 'wallinsx' variable as measured by surveyors in the EHS physical survey and refers to any insulation for the predominant wall type. The 'solid uninsulated' category includes non-cavity other wall types such as timber, steel or concrete framed. EFUS Interview 1 and Interview 3 questionnaires asked the household about the installation of wall insulation since the EHS survey and the 'wallinsx' variable was updated.
Loft insulation:	Banded variable of 'loftinsx', the level of loft insulation recorded by surveyors in the EHS physical survey. EFUS Interview 1 and Interview 3 questionnaires asked the household about the installation of loft insulation since the EHS survey and the 'loftinsx' variable was updated.
Long-term sickness or disability:	Whether anyone in household has long-term illness or disability that limits their activities. And/or whether anyone in the

Term	Description
	household is registered disabled. This is self-reported by EHS interview respondents.
Pensioner Present:	Anyone in the household who of state pension using data from the EHS Interview survey. Updates using responses to questions 45-50 in Interview 1 and questions 41-47 of Interview 3 EFUS questionnaires.
Region:	Government Office Region that the dwelling is located in. Obtained from the EHS.
Rurality:	Is the dwelling in a rural (village or isolated hamlet) or urban (urban or town or fringe) location. Derived from the 'rumorph' variable in the EHS.
SAP rating:	The energy cost rating as determined by Government's Standard Assessment Procedure (SAP) and is used to monitor the energy efficiency of dwellings. It is an index based on calculated annual space and water heating costs for a standard heating regime and is expressed on a scale of 1 (highly inefficient) to 100 (highly efficient with 100 representing zero energy cost). An updated SAP rating was modelled for dwellings which had improvements between EHS and EFUS Interviews 1 and 3.
Supplementary heating:	Heating systems used in addition to the main heating system to boost internal temperatures.
Tenure:	Derived from the EHS but updated from householder responses in EFUS to q52 in Interview 1 and Q51 of the Interview 3. Cases responding 'don't know' left as the original EHS category. The modelling assumes a response of 'renting' to be a household living in the private rented sector.
Type of (main) heating system:	Derived from the EHS but adjusted for EFUS Interview 2 and Interview 3 responses (question 02). Grouped into central heating or non-central heating categories. Non-central heating includes storage radiators, gas fires, electric heaters, coal/wood/ smokeless fuel fires or stoves and other less common systems.
Under-occupying:	A household is considered to be under-occupying if the dwelling is more than large enough for the number (and type) of occupants living there. For the full definition of under occupancy, see the fuel poverty methodology handbook, which is available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/829010/Fuel_Poverty_Methodology_Handbook_2019.pdf

Term	Description
	Derived from EHS data and updated based on age and household changes at EFUS Interview 1 and 3.
Useable floor area:	The total usable internal floor area of the dwelling as modelled for the EHS ‘floorx’, rounded to the nearest square metre. It excludes integral garages, balconies, stores accessed from the outside only and the area under partition walls. Grouped into 6 categories.
Water heating system	Derived from EHS data. Categories are: ‘with central heating’, ‘dedicated boiler’, ‘electric immersion heater’, ‘instantaneous’, ‘other’.

Appendix A – Appliance Ownership

Table A.1 shows the number and percentage of householders that reported owning, and using, at least one of each appliance, as asked during Interview 1.

Table A.1: Summary of ownership of a least one of each domestic appliance householders were asked to report on in Autumn 2017

	Sample size	Percent (%)
Combined washing machine and tumble dryer	*282*	13.2
Washing machine	*2,274*	84.4
Tumble dryer	*1,281*	45.8
Dishwasher	*988*	44.3
Fridge freezer	*1,763*	65.8
Separate fridge with small ice-box freezer	*456*	18.1
Separate fridge without small ice-box freezer	*564*	22.8
Separate freezer	*1,017*	38.2
American style fridge-freezer	*188*	7.4
TV	*2,542*	96.1
Digital TV box	*1,892*	71.7
Games console	*1,021*	36.3
Laptop	*1,810*	71.8
Mobile phone	*2,462*	94.0
Tablet	*1,696*	66.9
Internet connected speaker	*277*	12.5
Gas oven	*721*	24.5
Electric oven	*1,837*	72.6
Gas hob	*1,330*	54.0
Electric hob	*1,060*	38.3
Gas grill	*510*	17.3
Electric grill	*1,216*	48.2
Aga	*75*	3.1
Microwave	*2,075*	77.0
Combi microwave	*348*	14.4
Portable fan	*1,319*	50.1
Other fixed fan	*148*	5.0
Fixed air conditioning	*14*	0.7
Portable air conditioning	*44*	1.6
Humidifier	*22*	0.8
Dehumidifier	*57*	2.7
Extractor fan	*131*	4.5

Base: all households (n=2,632), Interview 1.

Table A.2 shows the number and percentage of householders that reported owning, and using, at least one of each appliance, as asked during Interview 1, condensed into categories to allow for comparison with ownership reported during the 1998 and 2011 energy follow up surveys.

Table A.2: Summary of ownership of a least one of each domestic appliance, 1998, 2011 and 2017

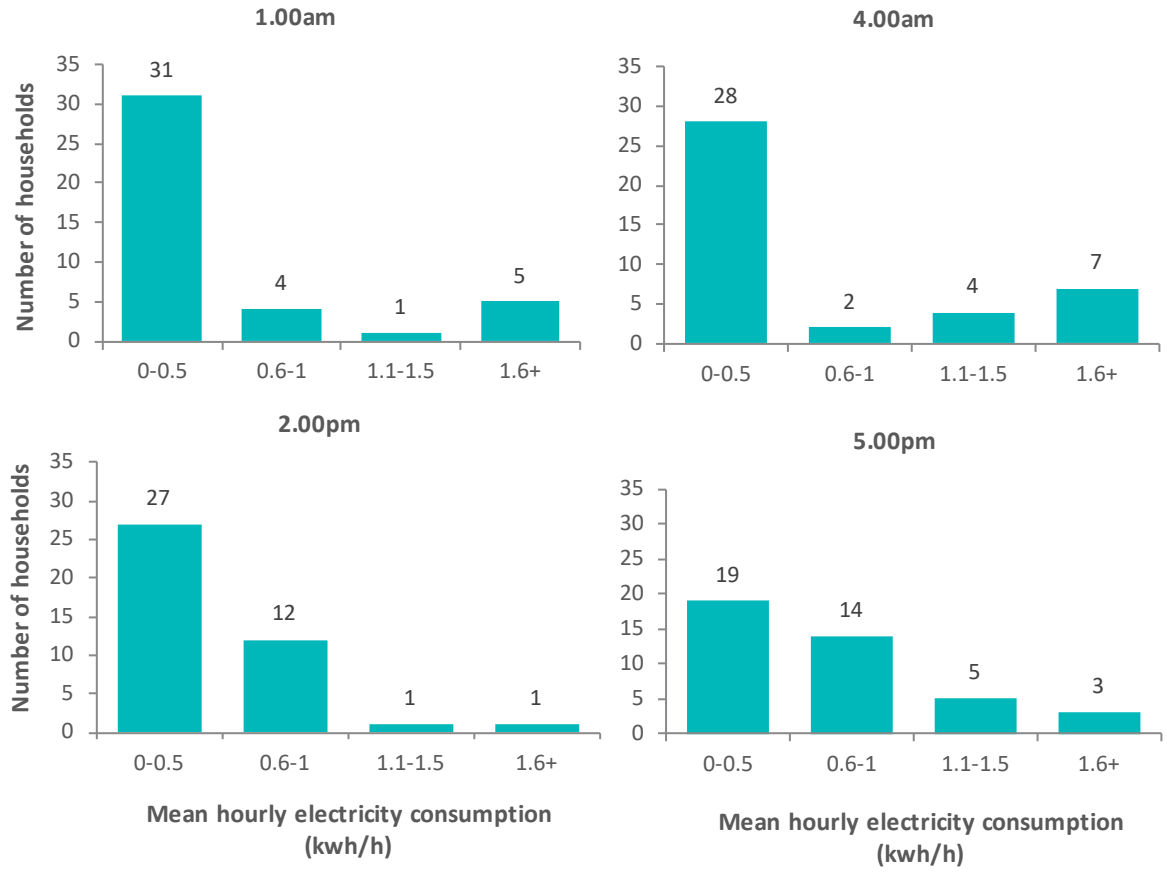
	1998		2011		2017	
	Sample size	Percent (%)	*Sample size*	Percent (%)	*Sample size*	Percent (%)
Combined washing machine and tumble	*309*	14.6	*325*	13.6	*282*	13.2
Washing machine	*2,057*	77.4	*2,202*	83.5	*2,274*	84.4
Tumble dryer	*913*	35.5	*1,227*	46.7	*1,281*	45.8
Dishwasher	*411*	21.4	*929*	38.5	*988*	44.3
Fridge freezer	*1,541*	58.0	*1,718*	64.9	*1,920*	72.0
Separate fridge	*1,178*	47.6	*1,133*	44.4	*957*	38.4
Separate freezer	*1,106*	47.3	*1,203*	46.1	*1,017*	38.2
TV	*2,580*	98.8	*2,570*	97.9	*2,542*	96.1
Oven	*2,432*	94.0	*2,397*	91.7	*2,525*	95.8
Hob	*2,442*	94.2	*2,408*	92.0	*2,372*	91.5
Grill	-	-	*1,756*	67.1	*1,708*	64.8
Aga	*51*	1.6	*95*	4.0	*75*	3.1
Microwave	*1,902*	73.9	*2,088*	79.8	*2,381*	89.7
Portable fan	-	-	*1,146*	43.3	*1,319*	50.1
Fixed fan	-	-	*232*	8.8	*148*	5.0
Fixed air conditioning	-	-	*17*	0.8	*14*	0.7
Portable air conditioning	-	-	*50*	2.0	*44*	1.6

Base: all households (n=2,619 EFUS 1998, n=2,616 EFUS 2011, n=2,592-2,632, EFUS 2017) EFUS 1998, EFUS 2011 and Interview 1.

Appendix B – Frequency Distribution of Electricity Consumption for households with Electric Heating Systems

Figure B.1 shows the distribution of electricity consumption values at 01:00, 04:00, 14:00 and 17:00 to investigate differing peaks in consumption for households with different types of electric heating systems. The exploratory analysis in Figure B.1 is based on small sample sizes and unweighted data, therefore care must be taken when drawing conclusions.

Figure B.1: Distribution of electricity consumption at 1.00am, 4:00am, 2:00pm and 5:00pm



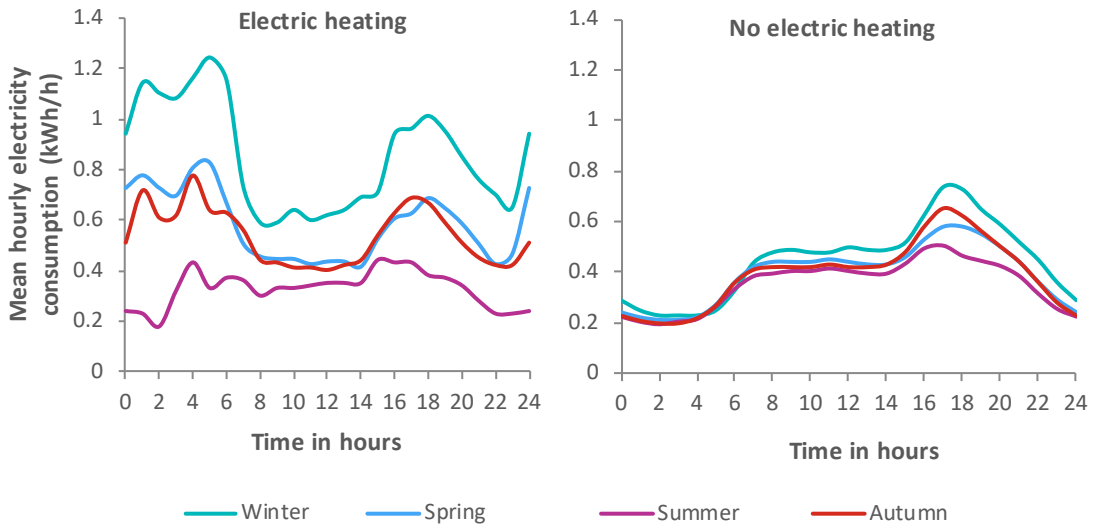
Base: all households with electricity consumption data, main fuel is electric (n=41).

During the early hours (01:00 and 04:00), the mean consumption of most households was under 0.5 kWh, with a small number showing large levels of consumption (over 1 kWh), these are likely to be households with storage heaters. During daytime hours, the mean consumption of the majority of households was under 1 kWh, with a small number of households exceeding 1 kWh at 17:00, a peak usage time according to median daily profiles (Figure 6.12).

Appendix C – Mean Daily Profiles of Households with Electric Heating

The mean daily profile of households with electricity as their main heating fuel (Figure 6.13) shows a considerably different trend, particularly in the early hours of the morning, compared with the median daily profile of households with electricity as their main heating fuel (Figure 6.12). The following appendix presents the mean daily profiles of households with electricity as their main heating fuel split by seasons (Figure C.1), months (Figure C.2) and during the coldest week of the EFUS monitoring period (Figure C.3). This mirrors the analysis done in Chapter 6 Section 6.4 and Section 6.5, that presents the median daily profiles of households for these time periods.

Figure C.1: Mean profile of mean hourly electricity consumption of households for the four seasons, 1st May 2018 to 30th April 2019, with and without electricity as their main heating fuel



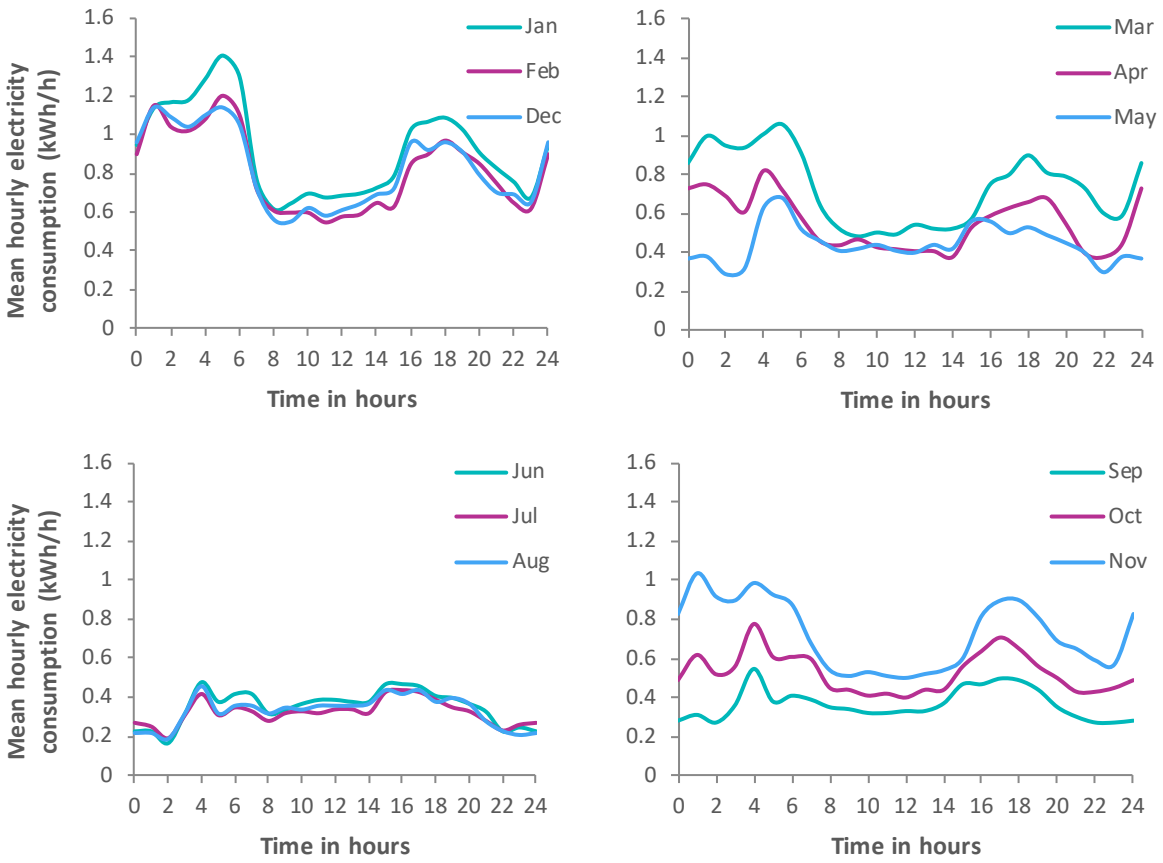
Base: all households with electricity consumption data for each season, main fuel is electric (n=38-41), main fuel not electric (n=359-392).

Figure C.1 shows how the mean daily profile changed between seasons. Households with electricity as their main heating fuel show two distinct peaks. The first peak occurred in the early hours of the morning, likely due to those with storage heaters charging these systems, and the second between 17:00 and 18:00, a peak that was also present for households without electricity as their main heating fuel. In winter, the peak over the early hours of the morning was larger and consumption was higher throughout the day compared with both other months for households with electricity as their main heating fuel, and the winter consumption of households without electricity as their main heating fuel. The mean daily profiles for spring and autumn are comparable, with consumption over the early morning and evening peaks at a

similar level. In summer, although the two peaks in consumption were still present, in general the consumption profile was much flatter, in line with the mean summer daily profile for households without electricity as their main heating fuel.

Figure C.2 shows how the mean daily profiles changed between the months within each season. Except for the summer months, which all show a generally flat consumption profile, the mean daily profiles for all months show the same trend, with a peak in the early hours of the morning and a peak in the evening. The winter months all show a similar level of consumption, with the highest consumption observed over the early hours for all months. For the spring and autumn months there was a shift from winter consumption patterns to summer consumption patterns. The consumption in March was in line with the winter months, then in April and May there was a decrease in the level of the early morning peak and the evening peak. The mean daily profile for May is quite flat after the early morning peak, similar to the profiles of the summer months. The mean daily profile for September is also quite flat, although consumption increased throughout the day, particularly in the early morning and evening peaks, for October and November.

Figure C.2 Mean profile of mean hourly electricity consumption of households for each month within each season, 1st May 2018 to 30th April 2019, with electricity as their main heating fuel

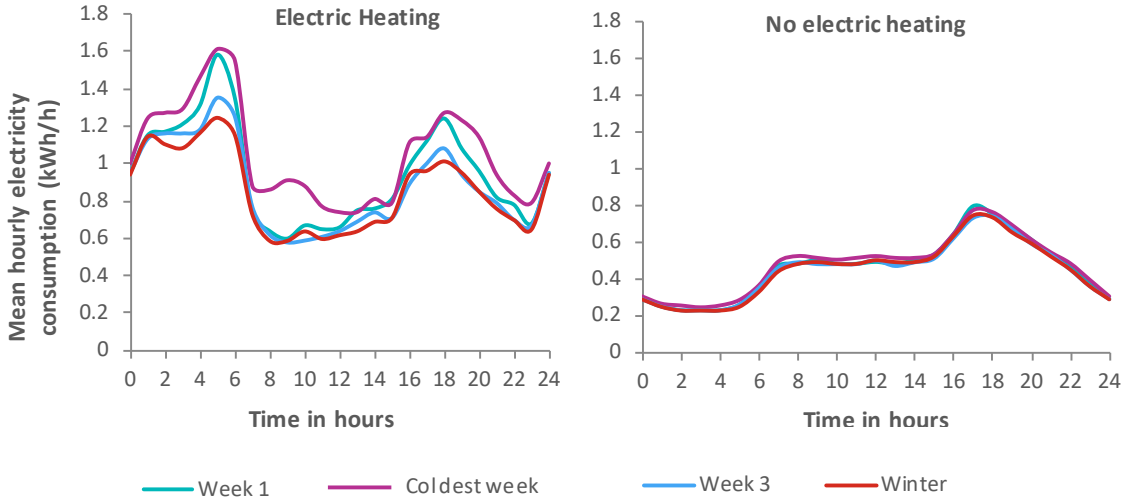


Base: all households with electricity consumption data for each month, main fuel is electric, (n=26-41).

Note: May and June profiles based on small sample sizes (n=26 May, n=29 June), indicative only.

Figure C.3 shows the mean daily profiles of households with and without electricity as their main heating fuel over the coldest week of the monitoring period, the week commencing 28th January 2019 (Week 2), when external temperatures averaged 0.9°C. Profiles for the coldest week are compared with the mean daily consumption profiles of the weeks either side, commencing 21st January 2019 (Week 1) and 4th February 2019 (Week 3) respectively.

Figure C.3 Mean profile of mean hourly electricity consumption of households, 21st January 2019 to 10th February 2019, with and without electricity as their main heating fuel



Base: all households with electricity consumption data for the coldest period over the monitored year and winter, main fuel is electric (n=39/n=39), main fuel not electric (n=379/n=387).

The consumption profiles of households without electricity as their main heating fuel were minimally affected by the changes in temperature over these three weeks, however the profiles of household with electricity as their main heating fuel were. During Week 1 there was an increase in consumption over the morning peak, particularly around 05:00, compared with the mean daily profile of winter, with the evening peak also at a higher level of consumption in Week 1 compared with the mean winter profile.

During Week 2 there was a further increase in consumption in the early morning, with a higher level of consumption also present across the late morning, which is not observed in any of the other profiles. The evening peak was at a higher level of consumption compared to the evening peak of the mean winter profile, the increased level of consumption is maintained until later in the evening compared with the evening peak in Week 1.

The consumption profile for Week 3 followed most closely to the mean daily profile for winter, suggesting that returning to typical winter habits, in terms of electricity consumption, occurred quite quickly after this cold spell.

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