



Report 2: Mean household temperatures

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Executive Summary

This report presents the headline results from an analysis of the mean room temperatures derived from the 2011 Energy Follow-Up Survey (EFUS). The 2011 EFUS consisted of a follow-up interview survey and associated monitoring of a sub-set of households first visited as part of the 2010/2011 English Housing Survey (EHS). Respondents who took part in the core EFUS survey were asked if they would consent to temperature loggers being installed in their home. Temperature loggers recorded temperatures at 20-minute intervals in the living room, hallway and main bedroom in 823 dwellings. These give a dataset of monthly mean temperatures in the three rooms, in zone 2 (average of the hallway and bedroom) and in the whole dwelling (average of all three rooms); as well as mean temperatures for the heating season and temperatures recorded during extreme cold and hot weather events. The analysis presented in this report uses temperatures collected during February 2011 to January 2012 data inclusive. Analysis is based on the sample weighted to the national level, using a weighting factor specific to the temperature logger sub-sample. The results presented in this report are therefore representative of the English housing stock, with a population of 21.9 million households.

The main findings of the analysis are:

- § Mean monthly temperatures for the whole dwelling range from 18.1°C in December to 21.5°C in July and August.
- § The mean monthly temperatures calculated from the EFUS data for the whole stock are between 0.1°C and 0.8°C higher for the months of heating than those calculated by SAP for a typical semi-detached house (using 2011 mean external temperatures), although the difference was negligible for November, December and January as the SAP values are within the bounds of the sampling error for the EFUS data.
- § On an individual room level, mean monthly temperatures in the living room are higher than in either the hallway or bedroom for the months of October through to March; while for the remaining months, mean monthly temperatures in the bedroom are typically the highest.
- § In the winter months, mean monthly temperatures in zone 1 are approximately 0.6°C higher than in zone 2. During the summer months the difference in temperature between zone 1 and zone 2 is not significant. In SAP, the calculated zone 1/zone 2 difference is between 0.7°C and 1°C higher than the mean difference determined from the EFUS data for the winter months.
- § In approximately 30% of households the mean monthly temperatures in zone 1 are lower than those in zone 2 (although the majority of households have zone 1 warmer than zone 2).
- § The mean room temperatures recorded during the heating season (October to April) are 19.3°C for the living room, 18.8°C for the hallway and 18.9°C for the bedroom, from which a mean temperature of 18.8°C for zone 2 and 19.0°C for the dwelling has been derived.
- § Approximately 65% of households maintain their living rooms and zone 2 areas within the range of 18-22°C during the heating season. However 26% of households maintain their

living rooms at temperatures below 18°C, while a further 7% of households heat their living rooms to temperatures at or above 22°C.

- § There are no statistically significant differences between weekday and weekend day mean heating season temperatures in the living room, bedroom, zone 2 or the dwelling as a whole.
- § The variations in mean heating season temperatures for different dwelling and household characteristics have been investigated. Dwellings that were fully double glazed, those with someone in during the day during a weekday, and those in which the occupants are not under-occupying have both living room and zone 2 mean heating season temperatures that are significantly higher than their alternative category.
- § Other significant differences that could be seen include dwellings built pre-1919 having lower mean heating season temperatures in both zones than dwellings built between 1945 and 1990; dwellings with a floor area <50m² having higher mean heating season temperatures in both zones than the largest dwellings with floor areas >140m²; owner-occupied dwellings having lower living room and zone 2 mean heating season temperatures than local authority or RSL dwellings and dwellings in which the Household Reference Person (HRP) is older than 75 years having higher living room and zone 2 mean heating season temperatures than dwellings with the HRP aged between 45-64 years.
- § Some groups of dwellings have significant differences in the mean heating season temperatures in one or other of the zones but not both:
 - Flats are seen to have higher living room mean heating season temperatures than detached or semi-detached dwellings but no difference is seen between dwelling types for zone 2 mean heating season temperatures.
 - Dwellings in rural locations tend to have lower zone 2 mean heating season temperatures than those in urban areas and dwellings in London tend to have higher zone 2 mean heating season temperatures than dwellings in the North West and Yorkshire and Humber regions but no differences are seen between the living room mean heating season temperatures for either characteristic.
 - Dwellings with no insulation measures have lower living room mean heating season temperatures than dwellings with at least one or more insulation measure, but no differences are seen in the zone 2 mean heating season temperatures for this characteristic.
 - Households with a pensioner living in the dwelling typically have higher living room mean heating season temperatures than households without a pensioner present; similarly households with one or more persons retired have higher living room mean heating season temperatures than households with one or more persons working full time. No differences in the mean heating season temperatures in zone 2 are seen for any of these groups.
- § For some groups there are no significant (or very small) differences in mean heating season temperatures: these are centrally heated versus non-centrally heated dwellings, dwellings using different fuels for their main heating; cavity insulated walls versus non-insulated walls,

differing levels of loft insulation, households of differing sizes, households with and without children present, households in all income quintiles and households in fuel poverty under the Low Income High Costs (LIHC) indicator.

- § The coldest days over most of the country were a period at the end of January 2011 and a period at the beginning of March 2011. Analysis of the EFUS data shows that temperatures collected during the January cold period are significantly lower than the average heating season temperature in all rooms. However the difference significance is not apparent for all rooms during the March period.
- § The hottest conditions occurred across most of the country on the 26-27 June 2011. Temperatures recorded in the dwellings during the hot spell are significantly higher than the summer average.

The key implications for the energy modelling methodologies of SAP/BREDEM are as follows:

- § The typical difference in the zone 1/zone 2 mean temperature calculated in the models may be an over-estimate. The results from the temperature monitoring suggest that zone 2 temperatures may be closer to the zone 1 temperatures than currently predicted by these models. Additional work in this area, however, required to fully understand what might cause these differences.
- § The difference between weekday/weekend day mean dwelling temperatures currently implemented in SAP may not be necessary. This supports the results presented in the Main Heating report, in that householders report little change in the number of hours that their heating is on between weekdays and weekends.
- § The monthly mean dwelling temperatures recorded during the EFUS 2011 match relatively well with the values calculated in SAP. The EFUS provides evidence for higher temperatures in summer compared to those used in SAP (due to a cap set in SAP) which, although not relevant to heating costs, may have implications for cooling costs in the future.

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1 Introduction

The main aim of the 2011 Energy Follow-Up Survey (EFUS) was to collect new data on domestic energy use, in order to update the current modelling assumptions about how energy is used in the home, and to inform energy efficiency policy. The 2011 EFUS consisted of a follow-up interview survey of a sub-set of households first visited as part of the 2010/2011 English Housing Survey (EHS). Additionally, sub-samples of these households were selected to have temperature loggers and electricity consumption monitors installed. A further stage of the EFUS was the compilation of gas and electricity consumption data from meter readings.

This report focuses specifically on the analysis of the mean dwelling temperatures derived from the temperature monitoring data. Analysis is based on the temperature logger sub-sample weighted to the national level, using a weighting factor specific to the temperature logger sub-sample. The results presented in this report are therefore representative of the English housing stock, with a population of 21.9 million households.

The outcomes of this analysis will be used to inform and update assumptions within BREDEM and SAP, and to inform energy efficiency policy.

The primary energy modelling techniques used in the UK are the BRE Domestic Energy Model (BREDEM), and its derivative the Standard Assessment Procedure (SAP)¹. These methodologies are extensively used to predict the annual energy consumption in dwellings; BREDEM includes estimates for space and water heating, lighting, electrical appliances and cooking energy use; whereas SAP includes space and water heating and lighting energy use. CO₂ emissions can be deduced directly from energy use, and the prediction of housing-related CO₂ emissions through to 2050 will continue to rely heavily on the SAP and BREDEM methodologies. The key component of these models is the space heating equation. The calculation of this equation depends on the mean internal temperature, the mean useful gains, the specific heat loss for the dwelling and the mean external temperature. A two-zone model is used for space heating, zone 1 representing the living area, and zone 2 representing the rest of the house. The space heating equation is applied separately to each zone, taking into account the transfer of heat between the zones. In BREDEM, the mean internal temperature in each zone is calculated using geometrical relationships based on an idealised temperature time graph, in which a dwelling is heated to a 'demand temperature' and, when the heating is off, the temperature falls back to (or near to) the 'background temperature'. The calculation of the 'mean internal temperature' is a function of the heating pattern and depends on the time taken for the dwelling temperature to fall from the demand temperature to the background temperature.

In BREDEM the usual value for the zone 1 demand temperature is 21°C, although any other figure may be entered if this value is believed to be more appropriate. The demand temperature in zone 2 is not precisely defined. Typically, the zone 2 demand temperature is 3°C lower than that in zone 1; however in practice, BREDEM assumes imperfect control in zone 2 so the actual demand temperature is higher than the design demand temperature. The background temperature depends on the heating system because an unresponsive heating system (e.g. an old, large-volume storage

¹ Details of SAP can be found in the SAP 2009 Specification. DECC/BRE, 2011.

Details of BREDEM can be found in the BREDEM 2012 Technical Specification, Henderson, J & Hart, J. BRE, 2013.

heater) will continue to output heat outside the heating period. Because of the different demand temperatures in each zone, this will typically lead to different background temperatures in each zone. For a fully responsive heating system, e.g. a gas boiler with radiators, the background temperature is equal to the external temperature plus the temperature rise resulting from useful gains, and is the same for both zones.

A key component of this analysis process has been the linkage of the EFUS data to key dwelling and household descriptor variables collected in the interview and physical survey components of the 2010 English Housing Survey (EHS). In this report, and the majority of the companion reports in this EFUS series, simple bivariate comparisons between the variable under consideration and individual descriptor variables have been performed in order to provide preliminary results and identify bivariate trends. It should be recognised, however, that subsequent investigations using more sophisticated statistical analysis may assist in the interpretation of results.

Other reports in this series cover the analysis of additional data derived from the temperature monitoring data, specifically the details of heating patterns and achieved temperatures can be found in the Main Heating Systems report, and an analysis of the risk posed from overheating can be found in the Thermal Comfort and Overheating report.

2 Methodology

A summary of the methodology of particular relevance to this report is provided below. Additional details, including the full interview questionnaire, can be found in the Methodology report.

The EFUS 2011 interview survey was undertaken by interviewers from GfK NOP between December 2010 and April 2011. A total of 2,616 interviews were completed, drawn from a sample from the 2010/11 English Housing Survey (EHS). Ahead of the interview fieldwork, all interviewers were assigned a batch of temperature loggers which they attempted to install during the course of their interviews. They also received training on installing the loggers appropriately. During the EFUS interview survey householders were asked if they would like to take part in the temperature monitoring component. Those that expressed interest then had temperature monitors installed by the interviewer (if the interviewer had not already exhausted their allocation of loggers). Of the 2,616 households interviewed, 943 households received temperature loggers. Up to three temperature loggers were to be placed in the main bedroom, hallway and living room of these households. These rooms were selected as they represent the key living spaces in dwellings. There were a small number of households without all three rooms (e.g. bedsits) which received only two loggers. The interviewers were instructed to place the loggers on internal walls out of direct sunlight and away from sources of heat. The temperature loggers were programmed to record data every 20 minutes and had a capacity of over one year's worth of data.

Loggers were installed in the dwellings during the period from December 2010 until April 2011, and householders returned the loggers to BRE in April/May 2012. A total of 118 sets of loggers failed to be returned and two sets were returned with all three loggers faulty. Thus the total number of sets of loggers adequate for analysis is 823. Of the 823 sets returned to BRE, 763 households returned three loggers, 57 households returned two, and three households returned one logger. On processing the logger outputs, it was found that 15 dwellings had one or more loggers that became faulty during the monitoring period; three dwellings had one or two loggers that failed to record from the outset and three households returned their loggers early (one in October 2011 and two in December 2011). See Table 1 for a summary.

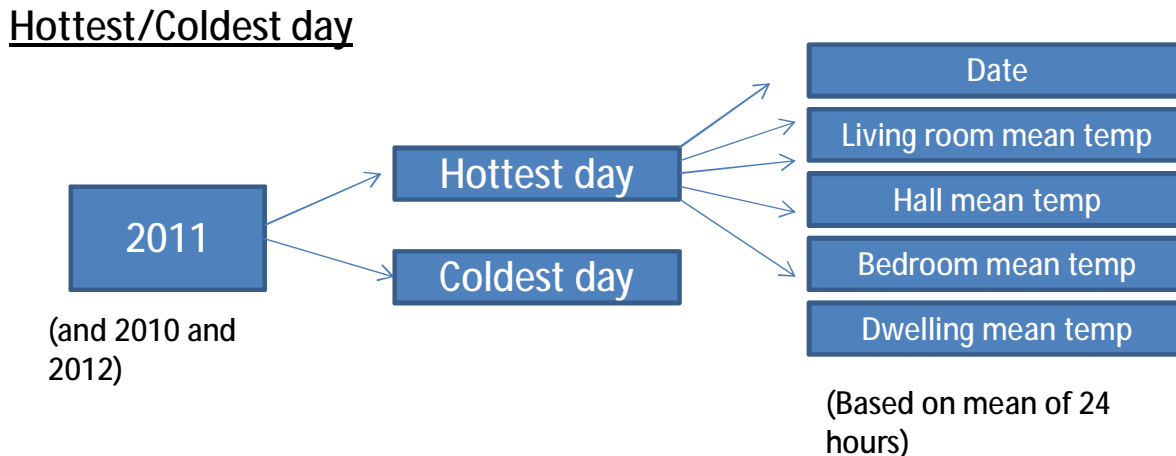
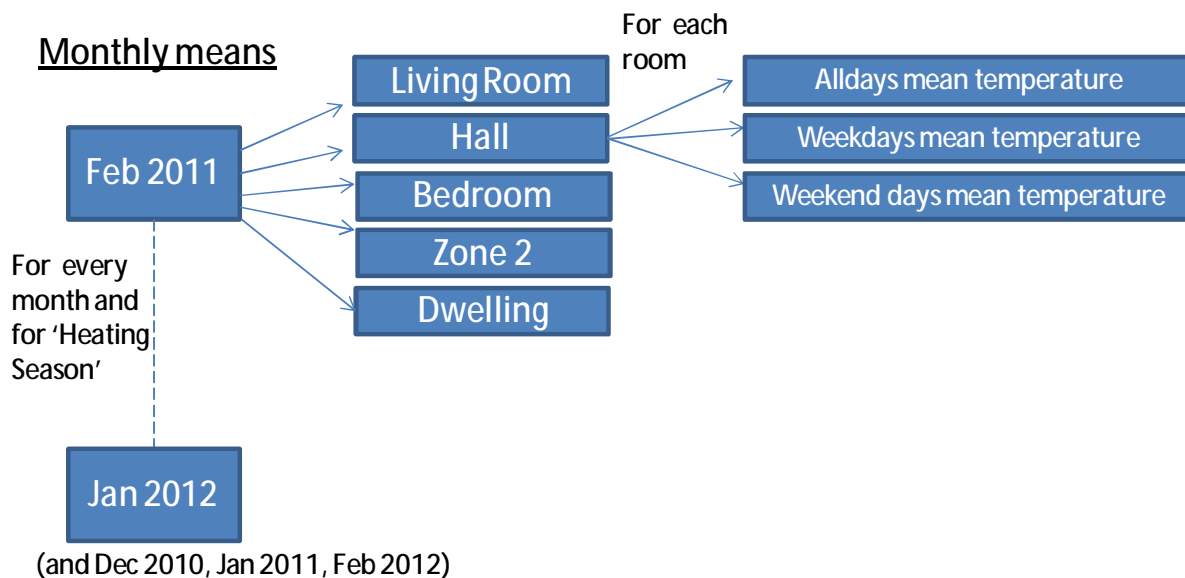
Table 1: Summary of loggers returned and analysed

Number of households with logger installed	943	
Number of households with no loggers returned/all faulty	120	
No. of households with 1 or 2 loggers returned	60	
No. of households with all 3 loggers returned	763	
Total Households Analysed	823	
<i>Of the 823 households analysed.....</i>		<i>% of total households analysed</i>
All returned loggers correct	802	97.4%
1 or 2 loggers failed to record at all	3	0.4%
Loggers returned early	3	0.4%
1 or more loggers became faulty during recording	15	1.8%

The temperature data was downloaded from the loggers, and processed to form key metrics, as outlined in Figure 1. Monthly mean temperatures for each household were calculated by averaging all the recorded temperatures obtained during that month; weekday means and weekend day

means used only the weekday and weekend recordings respectively². Weather data was obtained from the Met Office (MIDAS dataset). The Met Office station closest to each household on the EFUS dataset was identified (75% of EFUS cases were less than 15 miles from the nearest station) and the hourly external temperatures recorded by each station were time-matched to the temperature data recorded by the loggers.

Figure 1: Key metrics resulting from processing of the temperature loggers



The dates of the hottest/coldest days were obtained by locating the days on which the highest and lowest external temperatures occurred in each year. If these values occurred multiple times during the course of the year, the date of the first instance at which the temperature occurred was used. The room temperatures for these dates were calculated as the 24-hour mean for the date specified. In the cases where a logger failed at some point during the year, the monthly average for the month has been calculated using the recordings up to the point of failure. Averages after this time were set to missing.

Only 13% of dwellings had the loggers installed in December 2010, and while the majority were installed during January 2011, 20% of dwellings were still outstanding in this month. Additionally,

² due to the date of installation, means are calculated based on partial data for some months

apart from those faulty or returned early, all the loggers finished recording on 10th February 2012. Therefore, the analysis presented in this report is based on the months February 2011 to January 2012; and the hottest/coldest day analysis is for 2011 only.

2.1 Data quality

The quality of the data output from the loggers was generally good. For some dwellings it was noticed that for some months there were anomalous 'spikes' in the temperature readings, typically occurring at the same time each day for a few days, and which were presumably caused by direct sunlight hitting the logger. These were considered to have negligible effect on the calculation of the monthly averages, and no corrections were made.

2.2 Weighting factors

Weighting factors specific to the sample of households that received temperature loggers were derived using logistic regression based on the profile of respondents for the Government Office Region, tenure, dwelling type and working status of household. Although the objective of the weighting factor is to provide totals that can be interpreted at the national level, readers should be aware that there may remain some uncorrected bias in the data (e.g. if the households that accepted loggers differ from the population in a way that is not visible to the weighting procedure).

2.3 Temperature definitions

As described above, temperature loggers were placed in the living room, hallway and bedroom of each dwelling. In the following analysis, 'zone 2' temperatures refer to the mean of the hallway and bedroom temperatures and 'dwelling' temperatures refer to the mean of all three temperatures measured in the dwelling. For this analysis, a nominal 'heating season' has been taken to be the months of October to April following the responses given by household in the interview survey and identified by EFUS interview data³. Data from January 2012 has been used in this calculation, all other months being in 2011. The monthly mean temperatures reported in this work are calculated from the monthly mean temperatures for each household, averaged across all households (and weighted to the national level).

2.4 Outliers in the recorded temperatures

Appendix A includes detailed tables of descriptive statistics for the mean monthly temperatures for each room and it can be seen from looking at the 'minimum' and 'maximum' values that for all the rooms, some dwellings recorded monthly mean temperatures that could be considered 'outliers' compared to the typical dwelling temperatures expected during the heating season e.g. minimum hallway temperatures in February 2011 of 8.8°C, maximum hallway temperatures in January 2012 of 29.4°C. A more detailed inspection of dwellings with low monthly mean temperatures recorded during the winter months shows that although there were some dwellings in which these low monthly mean temperatures were recorded in all rooms (therefore suggesting that the dwelling was not being heated), there were also dwellings in which low monthly mean temperatures were recorded in one room, while the other rooms were being heated to more typical temperatures. Similarly, for the high monthly mean temperatures, there was no obvious indication that these were not the actual temperatures being attained in the dwelling. Additionally, there was not a significant

³ See Main Heating Systems report.

difference between the mean and the median average temperatures, the maximum difference being 0.2°C. Therefore no procedures have been implemented to remove or adjust these outlying values as it was felt that there was no compelling evidence to do so.

2.5 Calculating confidence intervals

All the confidence intervals presented in this report have been calculated using a design factor of 1.2 (see the Methodology report for further details).

3 Findings

Below are the key headline findings from the temperature data recorded as part of the EFUS survey. An initial summary of external weather conditions during the survey gives a context to the room temperatures reported. This is followed by analysis of monthly mean temperatures for the whole dwelling, for each room, and split by a nominal zone 1 and 2. Monthly mean room temperatures within a nominal heating season are then analysed, including the variation of mean heating season temperatures by dwelling and household characteristics. Finally, mean room temperatures during extreme external temperature conditions are reported.

3.1 Weather conditions during the survey

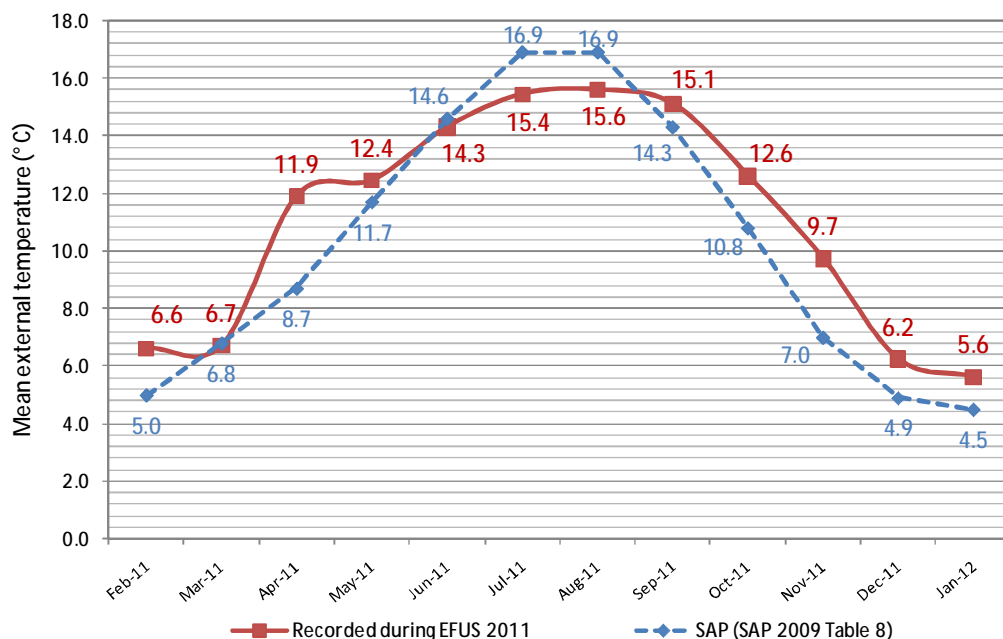
As discussed in the Methodology section above, monthly mean external temperatures were calculated for every dwelling using data from Met Office weather stations. The range of monthly mean temperatures is presented in Appendix A and a graph of the mean external temperatures is shown in Figure 2. The following synopsis from the Met Office UK Climate summaries⁴ provides the general context for the sampling period.

December 2010 was exceptionally cold across the UK with mean temperatures 5.0 °C below average (1971 to 2000 averages); chilly conditions persisted in early January 2011, before a milder spell around mid-month and then a return to colder weather. Temperatures were generally above average in February. This was followed by a warm Spring, with mean temperatures 0.6 °C above average during March, 3.7 °C above during April and 1.0 °C above in May. Summer was cool compared to average with the mean temperature near average during June, 0.7 °C below average during July and 0.6 °C below in August. Autumn 2011 was warm, with mean temperatures 1.5 °C above average in September, 2.0 °C above in October and 2.9 °C above in November. A spell of exceptionally warm weather occurred in late September and early October. Winter 2011/12 was mild, especially across southern areas. After a mostly mild January 2012, the last few days saw the onset of a cold spell that lasted two weeks with some sharp frosts and snowfalls, especially over England. Mild weather then returned until the end of February 2012.

Figure 2 also shows the long-term monthly mean external temperatures used in SAP which highlights the differences in the temperatures recorded in 2011 compared to the long-term average.

⁴ Summarised from information presented at <http://www.metoffice.gov.uk/climate/uk/>. Contains public sector information licensed under the Open Government Licence v1.0.

Figure 2: Monthly mean external temperatures (average over England)



Base: All households in EFUS 2011 temperature sub-sample (n=823)

Source: External temperatures during EFUS 2011 obtained from Met Office (MIDAS dataset)

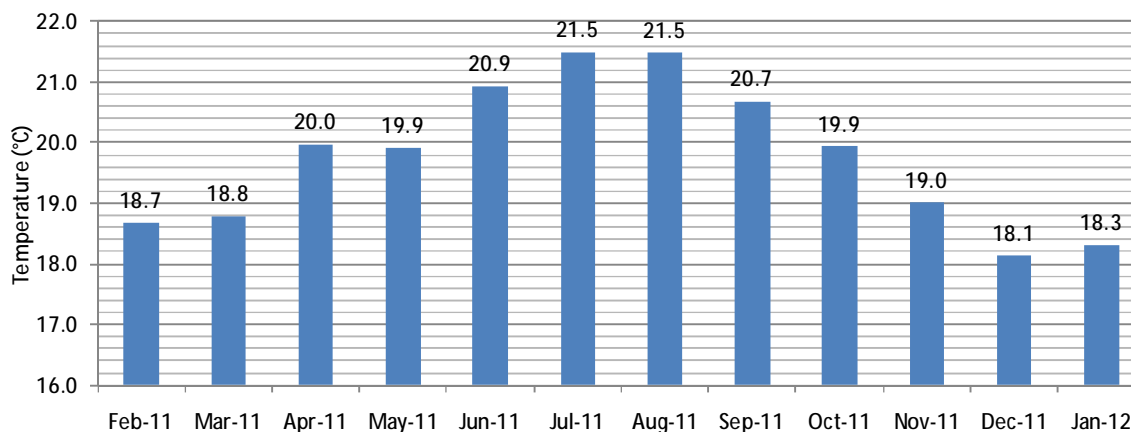
3.2 Summary of monthly mean room temperatures

As discussed above, the results presented here are for the 12 month period from February 2011 to January 2012.

3.2.1 Dwelling average

The average of the living room, hallway and bedroom monthly mean temperatures has been computed as the monthly mean 'dwelling' temperature and the variation by month is shown in Figure 3. Detailed tables of the descriptive statistics for the mean monthly temperatures for each room, zone 2 and the whole dwelling can be found in Appendix A.

Figure 3: Monthly mean temperatures for the dwelling



Base: All households in EFUS 2011 temperature sub-sample (n=823)

Monthly mean dwelling temperatures ranged from 18.1°C in December to 21.5°C in July and August. In SAP, the mean internal temperatures are calculated from an average of the 'living area' temperature and the 'rest of dwelling' temperature, weighted for the respective floor areas. The monthly mean internal temperatures calculated by SAP for a typical semi-detached house with stock average U-values and a typical gas heating system and a living area fraction of 0.25 are shown in Table 2. The first line in the table shows the mean internal temperatures calculated by SAP when using the long-term average external temperature. The second line shows the mean internal temperatures that would result from SAP if the SAP calculation procedure was forced to use the external temperatures recorded during the EFUS. Also shown in Table 2 are the 95% confidence intervals of the monthly mean dwelling temperatures recorded during EFUS 2011.

Table 2: Mean temperatures calculated in SAP 2009 and reported by EFUS 2011

Mean internal temperatures calculated in SAP 2009 (°C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dwelling Average ¹	17.7	17.9	18.2	18.6	19.1	19.6	19.8	19.8	19.4	18.8	18.2	17.8
Dwelling Average ²	18.0	18.2	18.3	19.1	19.3	19.5	19.6	19.6	19.6	19.2	18.7	18.1
EFUS monthly mean temperatures for the dwelling (°C)												
	Jan 2012	Feb 2011	Mar 2011	Apr 2011	May 2011	Jun 2011	Jul 2011	Aug 2011	Sep 2011	Oct 2011	Nov 2011	Dec 2011
EFUS dwelling average	18.3	18.7	18.8	20.0	19.9	20.9	21.5	21.5	20.7	19.9	19.0	18.1
EFUS 95% Confidence Intervals	(17.9, 18.6)	(18.3, 19.0)	(18.4, 19.1)	(19.7, 20.2)	(19.6, 20.1)	(20.7, 21.1)	(21.2, 21.7)	(21.2, 21.6)	(20.4, 20.9)	(19.6, 20.1)	(18.7, 19.3)	(17.7, 18.5)

Base: All households in EFUS 2011 temperature sub-sample (n=823)

¹ Calculated using the long term average weather data (Table 8 in SAP2009)

² Calculated using the Met office external weather data

It can be seen from comparing the values in Figure 3 and Table 2 that the temperatures calculated by SAP for this stereotypical dwelling using the long-term average weather data are lower than those calculated using the EFUS data for all months, although the difference is negligible for December as the SAP values are within the bounds of the sampling error for the EFUS data. When the SAP procedure is forced to use the external temperatures recorded during the EFUS, the resulting mean internal temperatures increase compared to the original for all months except for June-August, making the difference between the SAP values and the EFUS data negligible for November, December and January but still lower (by up to 1°C) for the remaining months. It should be noted that the monthly mean summer temperatures are not appropriate for comparison because they are limited to 21°C due to the nature of SAP's heating calculation. The limitations of this comparison should also be emphasised in that the results compare a stereotypical semi-detached home for the SAP calculation against the sample of dwellings monitored in the EFUS that are representative of the dwelling stock.

3.2.2 Room comparisons

The monthly mean room temperatures derived from the EFUS data for the living room, hallway and bedroom, along with the 95% confidence intervals are shown in Table 3 and Figure 4. As can be seen

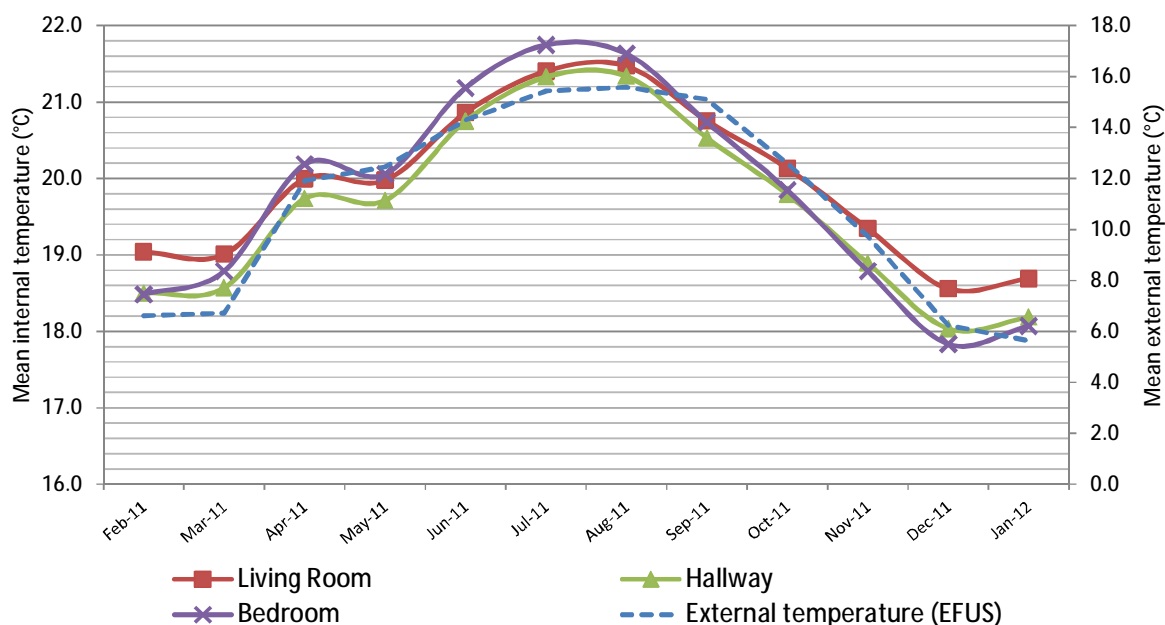
from Figure 4, both the lowest and highest monthly mean room temperatures were found in the bedroom, where monthly mean temperatures ranged from 17.8°C in December to 21.7°C in July. Monthly mean temperatures in the living room were higher than in either the hallway or bedroom for the months of October through to March while, for the remaining months, monthly mean temperatures in the bedroom were typically the highest.

Table 3: Monthly mean room temperatures

	Living Room (°C)		Hallway (°C)		Bedroom (°C)	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
Feb 2011	19.0	(18.8, 19.2)	18.5	(18.2, 18.7)	18.5	(18.2, 18.6)
Mar 2011	19.0	(18.8, 19.2)	18.6	(18.3, 18.7)	18.8	(18.5, 18.9)
Apr 2011	20.0	(19.8, 20.1)	19.7	(19.5, 19.8)	20.2	(20, 20.3)
May 2011	20.0	(19.8, 20.1)	19.7	(19.5, 19.8)	20.1	(19.9, 20.1)
Jun 2011	20.9	(20.7, 21)	20.7	(20.6, 20.8)	21.2	(21, 21.3)
Jul 2011	21.4	(21.2, 21.5)	21.3	(21.2, 21.4)	21.7	(21.6, 21.8)
Aug 2011	21.5	(21.3, 21.5)	21.3	(21.2, 21.4)	21.6	(21.5, 21.7)
Sep 2011	20.8	(20.6, 20.8)	20.5	(20.4, 20.6)	20.7	(20.6, 20.8)
Oct 2011	20.1	(19.9, 20.2)	19.8	(19.6, 19.9)	19.8	(19.7, 19.9)
Nov 2011	19.3	(19.1, 19.5)	18.9	(18.7, 19)	18.8	(18.6, 18.9)
Dec 2011	18.6	(18.3, 18.7)	18.0	(17.8, 18.2)	17.8	(17.6, 18)
Jan 2012	18.7	(18.4, 18.9)	18.2	(17.9, 18.4)	18.1	(17.8, 18.2)

Base: All households in EFUS 2011 temperature sub-sample (n=823)

Figure 4: Monthly mean room temperatures and external temperature recorded during EFUS 2011

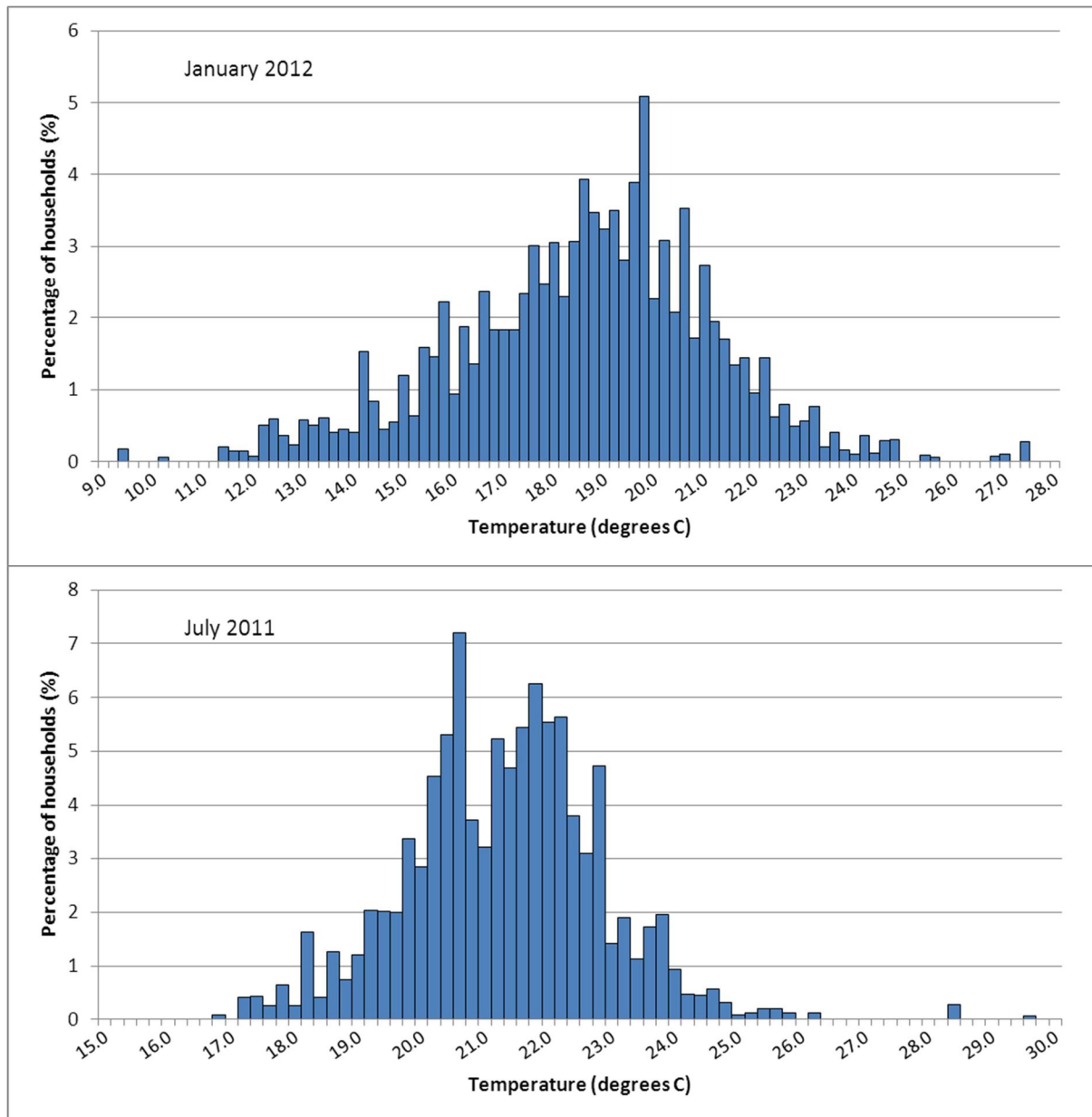


Base: All households in EFUS 2011 temperature sub-sample (n=823)

Examples of the underlying (derived) data on which these average statistics are calculated are shown in Figure 5. The first histogram shows the (weighted) percentage of monthly mean living room temperatures measured in households during January 2012, and the second histogram the same but

for July 2011 (note that these charts are shown with different scales for clarity). For both plots, the temperatures appear to be reasonably normally distributed, albeit with a very small positive skew and kurtosis. The histograms also provide evidence for the number of households with what could be considered 'outlying values', particularly for the winter months, for which there are a small number of dwellings (<1%) with average temperatures lower than 12°C and a slightly larger number of dwellings (8%) with average temperatures above 22°C.

Figure 5: Histogram of the monthly mean living room temperatures in a typical winter month (January 2012) and a typical summer month (July 2011)

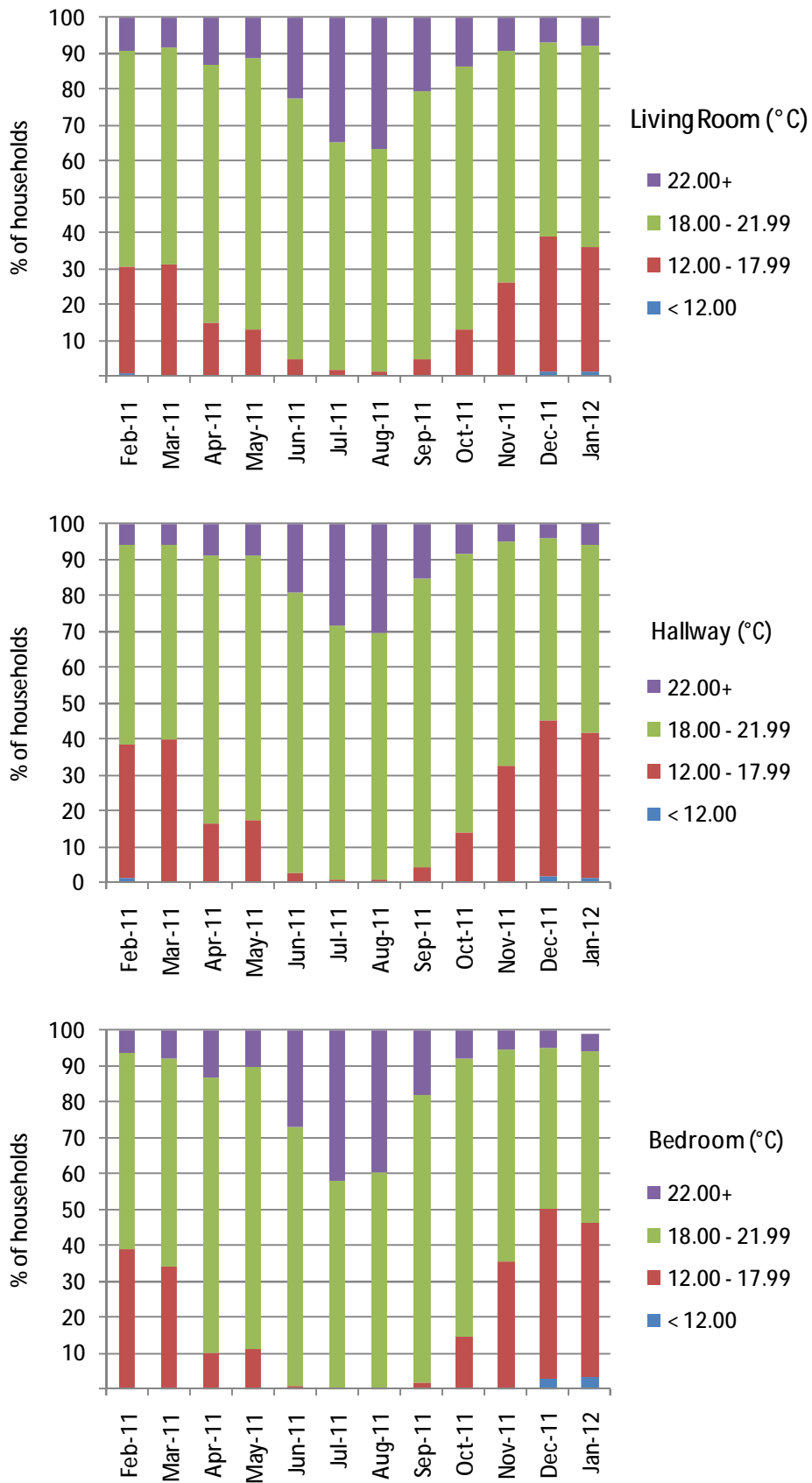


Base: All households in EFUS 2011 temperature sub-sample (n=823)

Figure 6 shows the monthly mean room temperatures grouped into four bands. For the winter months of December, January and February it can be seen that for all three rooms, between 1-3% of households had mean monthly temperatures below 12°C. A further 30-50% of households recorded monthly mean room temperatures between 12°C and 18°C for these same months. The proportion

of households with monthly mean room temperatures between 18°C and 22°C ranged from 45% in the bedroom in December to 60% in the living room in February and the proportion of households with monthly mean temperatures above this ranged from 4% to 9% in these winter months.

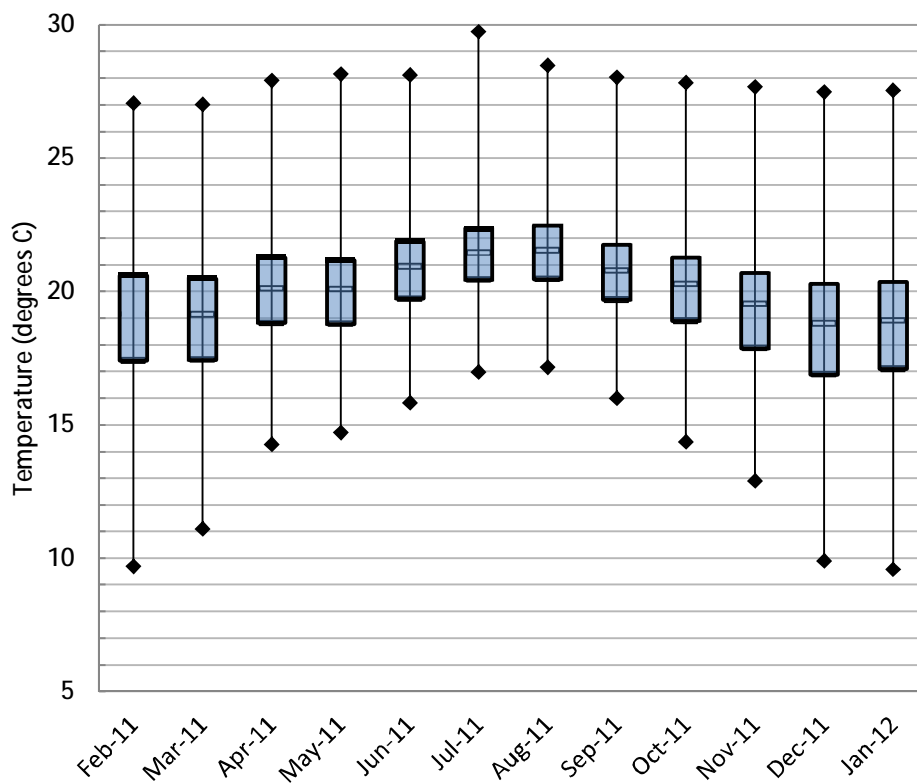
Figure 6: Distribution of monthly mean room temperatures in the living room (top), hallway (middle) and bedroom (bottom)



Base: All households in EFUS 2011 temperature sub-sample (n=823)

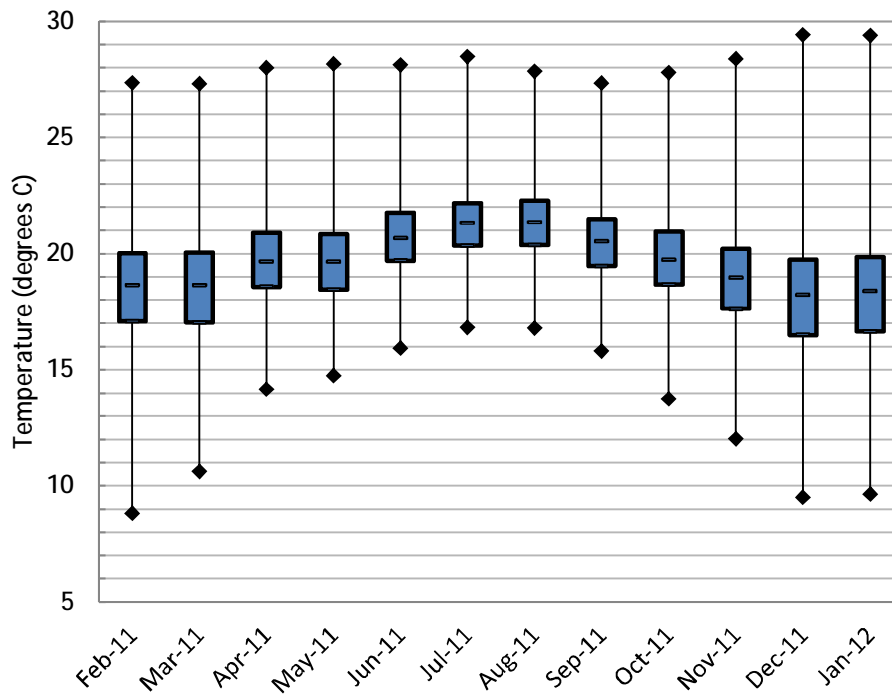
Figure 7 to Figure 9 show an alternative representation of the monthly mean living room, hallway and bedroom temperatures measured during the survey. The blue boxes represent the interquartile range (containing 50% of households) and the lines protruding from the box go out to the smallest and largest values. The position of the median value is also marked by the line at the centre of each box. It can be seen that for all three rooms the variation in mean monthly temperature was smaller in the summer months when, presumably, the dwelling temperatures were driven predominantly by the external temperature conditions. The extremely high monthly mean temperatures recorded in some dwellings in all three rooms during the summer months suggest that occupants of these dwellings may suffer from overheating. Approximately 1% of households recorded a monthly mean living room temperature of 25°C or higher during Jun/Jul/Aug. This issue is further discussed in the EFUS 2011 Thermal Comfort report.

Figure 7: Boxplot of the monthly mean temperatures in the living room



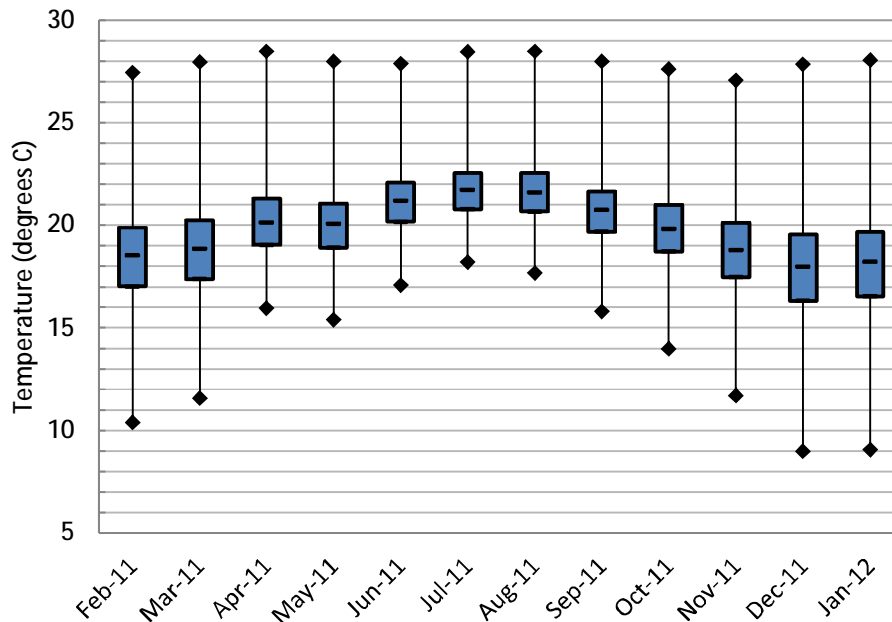
Base: All households in EFUS 2011 temperature sub-sample (n=823)

Figure 8: Boxplot of the monthly mean temperatures in the hallway



Base: All households in EFUS 2011 temperature sub-sample (n=823)

Figure 9: Boxplot of the monthly mean temperatures in the bedroom



Base: All households in EFUS 2011 temperature sub-sample (n=823)

3.2.3 Zone 2

Zone 1 and zone 2 are the nomenclature used in BREDEM to describe different parts of the dwelling, where zone 1 is the main living area and zone 2 is the rest of heated area of the house. For this study, the average (mean) of the hall and bedroom temperatures has been taken as the proxy for the zone 2 temperature (although it should be noted that zone 2 covers all other heated rooms

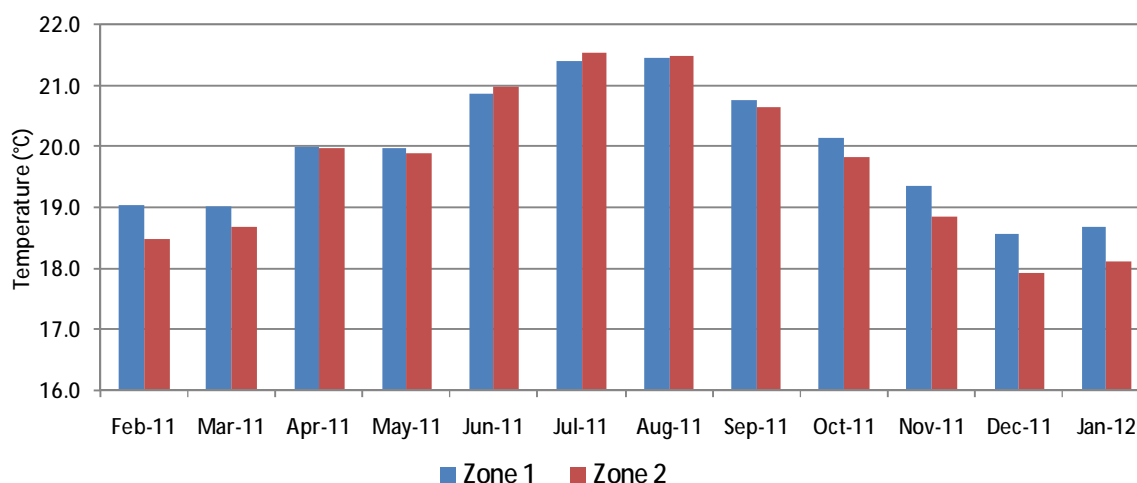
outside the main living area, rather than just the two monitored), and the living room temperature taken as the proxy for zone 1. The monthly mean temperatures for zone 2 and the 95% confidence intervals are shown in Table 4. Also shown in Table 4 is the mean monthly difference in zone 1 and zone 2 temperatures⁵. Comparison of the zone 1 and zone 2 temperatures for each month is shown in Figure 10 and from this, along with the results presented in Table 4, it can be seen that typically in the winter months, average temperatures in zone 1 were approximately 0.6°C higher than in zone 2. During the summer months the difference in temperature between zone 1 and zone 2 was not significant.

Table 4: Monthly mean temperatures for zone 1, zone 2 and the interzone difference

	Zone 1		Zone 2		Zone 1 – zone 2 difference	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
Feb 2011	19.0	(18.8, 19.2)	18.5	(18.2, 18.7)	0.6	(0.4, 0.7)
Mar 2011	19.0	(18.8, 19.2)	18.7	(18.4, 18.9)	0.3	(0.2, 0.4)
Apr 2011	20.0	(19.8, 20.1)	20.0	(19.7, 20.1)	0.0	(0, 0.1)
May 2011	20.0	(19.8, 20.1)	19.9	(19.6, 20)	0.1	(0, 0.1)
Jun 2011	20.9	(20.7, 21)	21.0	(20.7, 21.1)	-0.1	(-0.1, 0)
Jul 2011	21.4	(21.2, 21.5)	21.5	(21.3, 21.7)	-0.1	(-0.2, 0)
Aug 2011	21.5	(21.3, 21.5)	21.5	(21.3, 21.6)	0.0	(0, 0)
Sep 2011	20.8	(20.6, 20.8)	20.6	(20.4, 20.8)	0.1	(0, 0.1)
Oct 2011	20.1	(19.9, 20.2)	19.8	(19.6, 20)	0.3	(0.2, 0.3)
Nov 2011	19.3	(19.1, 19.5)	18.8	(18.5, 19)	0.5	(0.3, 0.6)
Dec 2011	18.6	(18.3, 18.7)	17.9	(17.6, 18.2)	0.6	(0.4, 0.7)
Jan 2012	18.7	(18.4, 18.9)	18.1	(17.8, 18.4)	0.6	(0.4, 0.7)

Base: All households in EFUS 2011 temperature sub-sample (n=823)

Figure 10: Distribution of monthly mean temperatures in zone 1 and zone 2

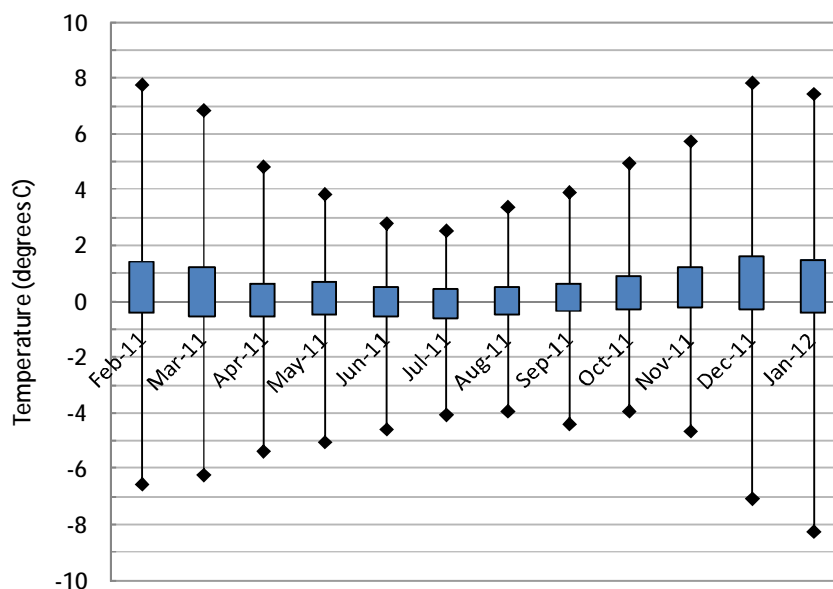


Base: All households in EFUS 2011 temperature sub-sample (n=823)

⁵ Difference is calculated as zone 1 minus zone 2.

The differences in zone 1/zone 2 monthly mean temperatures are shown in Figure 11 and Table 5. It can be seen that on average over the year, 29% of households have mean monthly temperatures that were lower in zone 1 than in zone 2, the majority (53%) keeping zone 1 warmer than zone 2 and the remaining 19% of households have no difference between the zones⁶.

Figure 11: The mean monthly temperature difference between zone 1 and zone 2



Base: All households in EFUS 2011 temperature sub-sample (n=823)

Table 5: Spread of difference in zone 1/ 2 mean monthly temperatures for each month (% of households)

	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Average over year
Zone 1 more than 3°C colder	*3	*3	*2	*1	*1	*1	**	**	**	*1	*3	*4	*1
Zone 1 2°C to 3°C colder	*3	*4	*3	*2	*4	*3	*2	*1	*2	*2	*3	*4	*2
Zone 1 1°C to 2°C colder	9	10	11	8	10	10	10	8	7	8	8	8	9
Zone 1 up to 1°C colder	14	16	23	25	28	31	27	23	18	16	13	14	17
No difference	12	12	16	18	23	21	23	24	18	11	9	9	19
Zone 1 up to 1°C warmer	21	25	30	30	26	25	28	29	35	32	27	25	31
Zone 1 1°C to 2°C warmer	22	18	12	13	9	8	9	14	16	20	19	18	17
Zone 1 2°C to 3°C warmer	8	6	4	3	*1	*1	*1	*1	4	7	10	10	4
Zone 1 more than 3°C warmer	8	6	**	**	**	**	**	**	*1	4	8	8	1
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

Base: All households in EFUS 2011 temperature sub-sample (n=823)

*Sample responses are very small and subject to large sampling errors

**Within the sample there were no responses for this combination but this is not necessarily true for the population. The probability of this combination occurring in the population is likely to be <0.5%.

⁶ Percentages do not add to 100 due to rounding.

Table 6 shows the typical mean internal temperatures in zones 1 and 2 as calculated by SAP 2009 for a typical three bedroom semi-detached dwelling⁷, as well as the difference in temperatures between the zones. The SAP calculation predicts a 1.3°C temperature difference between the zones in the months of heating⁸. For ease of comparison, the monthly mean zone 1 and zone 2 temperatures determined from the EFUS 2011 temperature data are also shown in the table. It can be seen that the SAP-calculated zone 1/zone 2 difference is between 0.7°C and 1.4°C higher than the mean difference determined from the EFUS data for the winter months. However, as before, the limitations of this comparison should also be emphasised in that the results compare a stereotypical semi-detached home for the SAP calculation against the sample of dwellings monitored in the EFUS that are representative of the dwelling stock.

Table 6: Typical zone 1 and zone 2 mean internal temperatures as calculated in SAP 2009 and reported by EFUS 2011

	Mean internal temperatures calculated in SAP 2009 (°C)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Living room	18.7	18.9	19.2	19.6	20.1	20.6	20.9	20.8	20.4	19.8	19.2	18.8
Rest of house	17.4	17.5	17.9	18.3	18.8	19.2	19.4	19.4	19.1	18.5	17.8	17.5
Difference between zone1- zone 2	1.3	1.3	1.3	1.3	1.3	1.4	1.5	1.4	1.3	1.3	1.3	1.3
	Mean monthly room temperatures determined from the EFUS 2011 temperature data (°C)											
Living room	19.0	19.0	20.0	20.0	20.9	21.4	21.5	20.8	20.1	19.3	18.6	18.7
Zone 2	18.5	18.7	20.0	19.9	21.0	21.5	21.5	20.6	19.8	18.8	17.9	18.1
Difference between zone1- zone 2	0.6	0.3	0	0.1	-0.1	-0.1	0	0.1	0.3	0.5	0.6	0.6

Base: All households in EFUS 2011 temperature sub-sample (n=823). For confidence intervals see Table 4 above.

Correlation between rooms

Scatter plots of the variation in monthly mean temperatures measured in the living room, hallway and bedroom for January 2012 and July 2011 are shown in Appendix B⁹. All the combinations suggest a positive correlation in temperatures between the rooms. The relationships between the monthly mean temperatures in each room for a typical winter (January) and summer (July) month were investigated using the Pearson product-moment correlation coefficient, the results of which are shown in Appendix B.

There is a strong positive correlation (significant at the $p < 0.01$ level) between all three rooms for both seasons. In January, the strongest correlation is seen between the hallway and the bedroom [$r = 0.748$, $n = 771$] and the weakest between the living room and bedroom [$r = 0.681$, $n = 771$]. Even stronger correlations are seen in summer, when the heating is off and monthly mean temperatures were driven predominantly by external conditions. In this case the correlation between the living

⁷ Values are for a typical semi-detached house with a gas heating system.

⁸ Additional calculations show that for a typical mid-terrace the difference is about 1.1°C and for a typical detached dwelling the difference is about 1.4°C

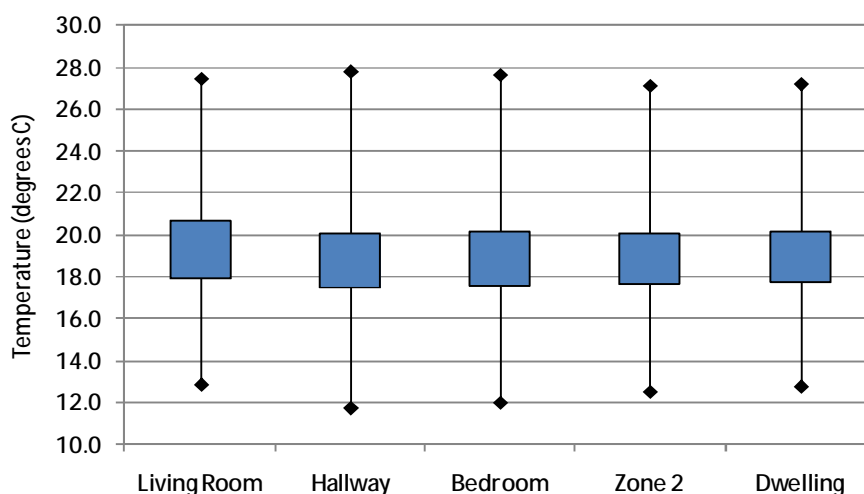
⁹ Correlations were performed on the unweighted sample.

room and the hallway is strongest [$r=0.807$, $n=774$], possibly because these rooms were likely to be in close proximity to each other.

3.3 Summary of mean room temperatures over a nominal heating season

As described in the methodology, the nominal 'heating season' has been defined as the months of October through to April, and the individual monthly temperatures have been averaged to produce the mean room temperature over the heating season. Average heating season temperatures have not been calculated for households with missing information for 1 or more of the months. Figure 12 shows boxplots of the minimum and maximum values and the interquartile ranges for each room. The mean room temperatures recorded during the heating season were 19.3°C for the living room, 18.8°C for the hallway and 18.9°C for the bedroom, the averages of which resulted in a mean temperature of 18.8°C for zone 2 and 19.0°C for the whole dwelling.

Figure 12: Boxplot of mean heating season room temperatures



Base: All households in EFUS 2011 temperature sub-sample (n=823)

As was done for the monthly temperatures, the mean temperatures recorded during the heating season in the living room (zone 1) and in zone 2 have been grouped into four bands around the indoor temperature range of 18-22°C, and the results are shown in Table 7. It can be seen from this table that approximately 65% of households maintained mean heating season temperatures in their living rooms and zone 2 areas within the range of 18-22°C. However 26% of households maintained mean heating season temperatures in their living rooms at temperatures below 18°C, while a further 7% of households heated their living rooms to a mean heating season temperature at or above 22°C. The proportions alter slightly for the zone 2 areas, which a slightly higher proportion of households maintain in the lower temperature range.

Table 7: Mean heating season room temperatures (banded) for the Living Room and Zone 2

Mean room temperature range	Living Room (%)			Zone 2 (%)		
	Sample size	%	95% C.I.	Sample size	%	95% C.I.
<12°C	0	0.0		0	0.0	
12°C - <18°C	194	25.9	(22.6,29.2)	249	30.4	(26.9,33.9)
18°C - <22°C	529	63.9	(60.3,67.5)	526	65.0	(61.4,68.6)
22+°C	75	7.5	(5.5,9.4)	46	4.5	(2.9,6.0)
Missing*	25	2.7	(1.5,4.0)	2	0.1	(0,0.4)
Total	823	100.0		823	100.0	

Base: All households in EFUS 2011 temperature sub-sample (n=823)

* Average heating season temperatures have not been calculated for households with missing information for 1 or more of the months

3.3.1 Weekdays and weekend days

Processing of the data also provides the average temperatures for weekdays and weekend days separately. BREDEM and SAP differentiate between these days by assigning different heating hours (specifically defined hours in SAP, with the option to define different hours on different days in BREDEM) and so it is of interest to investigate whether the temperatures do, in fact, differ. Comparison of the 95% confidence intervals (see Table 8) show that there were no statistically significant differences between weekday and weekend day mean heating season temperatures in the living room, bedroom, zone 2 or the dwelling as a whole.

Table 8: Weekday and weekend mean room temperatures during the heating season

	Weekday		Weekend	
	Mean room temperature °C	95% C.I.	Mean room temperature °C	95% C.I.
Living Room (N=798)	19.2	(19.0, 19.3)	19.4	(19.2, 19.5)
Hallway (N=801)	18.8	(18.5, 18.9)	18.9	(18.7, 19.1)
Bedroom (N=801)	18.8	(18.6, 18.9)	19.0	(18.8, 19.1)
Zone 2 (N=821)	18.8	(18.6, 18.9)	19.0	(18.8, 19.1)
Dwelling (N=823)	18.9	(18.7, 19.0)	19.1	(18.9, 19.2)

Base: All households in EFUS 2011 temperature sub-sample (n=823): unweighted sample

3.4 Variation of mean heating season temperatures by dwelling and household characteristics

It is of interest to energy efficiency policymakers to investigate whether mean room dwelling temperatures vary for different household and dwelling groups. Characteristics relating to the

physical properties of the dwelling, (e.g. type of heating system, insulation, dwelling age and type) and also to the households living within those dwellings (e.g. pensioner present, household income level, tenure) have been examined. The mean temperatures in the living room, hallway, bedroom, zone 2 (the average of hallway and bedroom), the overall dwelling average (from the three locations) are shown in Table 9. Table 10 shows the 95% confidence intervals of the mean temperatures for the living room and zone 2. The 95% confidence intervals show the significance of the differences across categories. Detailed descriptions of the variables used or derived from the EHS and EFUS data can be found in the Glossary.

The results show that dwellings that are fully double-glazed, those with someone in during the day during a weekday and those in which the occupants are not under-occupying have both living room and zone 2 mean heating season temperatures that are significantly higher than their alternative category. Other significant differences that can be seen include dwellings built pre-1919 having lower mean heating season temperatures in both zones than dwellings built between 1945 and 1990; dwellings with a floor area $<50\text{m}^2$ having higher mean heating season temperatures in both zones than the largest dwellings with floor areas $>140\text{m}^2$; owner-occupied dwellings having lower living room and zone 2 mean heating season temperatures than local authority or RSL dwellings; and dwellings in which the HRP is older than 75 years having higher living room and zone 2 mean heating season temperatures than dwellings with the HRP aged between 45-64 years.

There were also some groups of dwellings that have significant differences in the mean heating season room temperatures in one or other of the zones but not both. For example, flats are seen to have higher mean heating season living room temperatures than detached or semi-detached dwellings but no difference is seen between dwelling types in the zone 2 mean heating season temperatures. Dwellings in rural locations tend to have lower mean heating season zone 2 temperatures than those in urban areas, and dwellings in London tend to have higher mean heating season zone 2 temperatures than dwellings in the North West and Yorkshire and Humber regions, although no differences are seen between the living room mean heating season temperatures for either characteristic. Dwellings with no insulation measures have lower living room mean heating season temperatures than dwellings with at least one or more insulation measures, but no differences are seen in the zone 2 mean heating season temperatures for this characteristic. In terms of household characteristics, households with a pensioner living in the dwelling typically have higher living room mean heating season temperatures than households without a pensioner present; similarly households with one or more persons retired have higher living room mean heating season temperatures than households with one or more persons working full time. No differences in the mean heating season temperatures in zone 2 are seen for any of these groups.

Finally there were some groups for which there are no significant (or very small) differences in mean heating season temperatures: centrally heated versus non-centrally heated dwellings, dwellings using different fuels for their main heating; cavity insulated walls versus non-insulated walls, differing levels of loft insulation, households of differing sizes, households with and without children present, households in all income quintiles and households in fuel poverty under the Low Income High Costs (LIHC) indicator.

The mean external temperature has also been included in the table as it was noted that there was a difference in the external temperature for some of the groups, which could have been an influencing factor. Regression of the mean dwelling temperatures on external temperatures for the heating

season months shows that a 1°C rise in external temperature corresponds to a 0.24°C rise in dwelling temperature. If the fully double glazed/not fully double glazed comparison is taken as an example, standardisation of the living room temperatures to the stock mean heating season external temperature of 8.4°C results in virtually no change in temperatures. The only impact of standardisation was found to be for the regions, where standardisation resulted in a decrease in the mean heating season temperatures in London such that there was no real difference between London and the NW and Yorkshire and Humber for the zone 2 mean heating season temperatures.

Table 9: Mean temperatures (°C) during the nominal heating season by dwelling and household characteristics

Dwelling characteristic	Characteristic category	Mean temperature (°C)					
		Living Room	Hallway	Bedroom	Zone 2	Dwelling	External
Dwelling type	End terrace	19.0	18.7	19.0	18.8	18.9	8.5
	Mid terrace	19.5	19.1	19.0	19.0	19.2	8.5
	Semi detached	19.0	18.4	18.9	18.6	18.8	8.4
	Detached	18.7	18.4	18.6	18.5	18.6	8.4
	Bungalow	19.4	19.3	18.6	18.9	19.1	8.2
	Flat	20.0	19.5	18.9	19.3	19.5	8.8
Dwelling type	House or bungalow	19.1	18.7	18.8	18.7	18.9	8.4
	Flat	20.0	19.5	18.9	19.3	19.5	8.8
Dwelling Age	Pre 1919	18.3	18.1	18.0	18.0	18.1	8.5
	1919-1944	19.2	18.7	18.8	18.7	18.9	8.6
	1945-1964	19.6	18.8	19.1	19.0	19.2	8.4
	1965-1974	19.3	19.0	19.0	19.0	19.1	8.5
	1975-1980	20.1	19.7	19.6	19.7	19.8	8.6
	1981-1990	19.5	19.2	19.2	19.2	19.3	8.5
	Post 1990	19.2	19.2	19.1	19.1	19.2	8.5
Useable floor area	< 50 m ²	20.1	19.8	19.2	19.5	19.7	8.9
	50 to 69 m ²	19.4	18.9	18.9	18.9	19.1	8.4
	70 to 89 m ²	19.1	18.6	18.9	18.7	18.8	8.5
	90 to 109 m ²	19.5	18.9	19.0	18.9	19.1	8.5
	110 to 139 m ²	18.9	18.6	18.7	18.7	18.8	8.5
	≥140 m ²	18.7	18.4	18.4	18.4	18.5	8.3
Region - EHS order	North East	19.1	18.2	18.5	18.4	18.6	7.3
	North West	18.7	18.4	18.5	18.5	18.6	8.2
	Yorkshire and the Humber	18.8	18.3	18.2	18.3	18.5	7.6
	East Midlands	19.5	18.5	19.0	18.7	19.0	8.3
	West Midlands	19.0	18.4	18.8	18.5	18.7	8.2
	East	19.5	19.3	19.1	19.1	19.3	8.4
	London	19.9	19.9	19.4	19.7	19.8	9.6
	South East	19.5	19.2	19.2	19.2	19.3	8.8
	South West	19.1	18.5	18.6	18.6	18.8	9.1
Urban or rural location?	Urban	19.3	18.9	18.9	18.9	19.0	8.5
	Rural	19.0	18.2	18.3	18.3	18.5	8.4
Type of heating system	Central Heating	19.2	18.8	18.9	18.9	19.0	8.5
	Non-Central Heating	19.6	18.7	18.2	18.5	18.8	8.5
Main heating fuel	Mains gas	19.2	18.8	18.9	18.8	19.0	8.5
	Electricity	19.5	18.7	18.2	18.5	18.8	8.4
	Other (bottled/bulk gas, solid, oil, communal)	19.8	19.0	19.2	19.1	19.3	8.6
Are the walls of the dwelling insulated?	Insulated	19.4	18.9	19.1	19.0	19.1	8.3
	Not insulated	19.1	18.8	18.7	18.8	18.9	8.6
Loft insulation	<50mm	18.7	18.6	18.8	18.8	18.8	8.6
	50-149mm	19.2	18.7	18.9	18.8	18.9	8.5
	150+ mm	19.2	18.7	18.8	18.7	18.9	8.3
Is dwelling fully double glazed?	Yes	19.5	18.9	19.0	19.0	19.1	8.5
	No	18.7	18.5	18.4	18.4	18.5	8.6
Dwelling insulation	All 3 insulation measures	19.2	18.7	18.8	18.8	18.9	8.2
	2 insulation measures	19.5	18.8	19.1	19.0	19.2	8.4
	1 insulation measure	19.3	18.8	18.9	18.9	19.0	8.6
	No insulation measures	17.9	18.2	18.2	18.1	18.1	8.6
Energy efficiency (SAP09) rating	less than 30*	18.0	18.1	17.4	17.7	17.8	8.5
	30 to 50	18.9	18.3	18.6	18.5	18.6	8.5
	51 to 70	19.4	18.9	19.0	18.9	19.1	8.5
	more than 70	19.9	19.8	19.3	19.6	19.7	8.6

Table continued on next page

Table 9 continued: Mean room temperatures during the Heating Season (Oct – April, all days in month) by dwelling and household characteristics

Household characteristic	Characteristic category	Mean temperature (°C)					
		Living Room	Hallway	Bedroom	Zone 2	Dwelling	External
Tenure	Owner Occupied	19.0	18.7	18.8	18.7	18.8	8.5
	Private rented	19.3	18.6	18.7	18.7	18.9	8.6
	Local Authority	20.3	19.4	19.3	19.4	19.7	8.4
	RSL	20.0	19.7	19.1	19.4	19.6	8.5
Household size	1	19.0	18.5	18.3	18.4	18.6	8.4
	2	19.3	18.9	19.0	19.0	19.1	8.5
	3	19.4	19.2	19.0	19.1	19.2	8.6
	4	19.2	18.7	19.2	19.0	19.1	8.4
	5 or more	19.3	19.0	19.1	19.0	19.1	8.5
Pensioner Present?	At least one person of pensionable age	19.8	19.2	19.0	19.1	19.3	8.4
	No persons of pensionable age	19.0	18.6	18.8	18.7	18.8	8.5
Children Present?	At least one child	19.3	19.0	19.2	19.1	19.2	8.5
	No children	19.2	18.8	18.7	18.8	18.9	8.5
Age HRP	16 - 34	19.2	18.8	19.4	19.0	19.1	8.6
	35 - 44	19.0	18.7	18.7	18.7	18.8	8.6
	45 - 54	18.9	18.4	18.7	18.5	18.6	8.4
	55 - 64	19.1	18.7	18.6	18.7	18.8	8.6
	65 - 74	19.7	19.0	19.0	19.0	19.2	8.3
	75 or more	20.4	19.9	19.4	19.7	19.9	8.6
Employment status of HRP and partner combined	1 or more work full time	19.0	18.7	18.8	18.7	18.8	8.6
	1 or more work part time	19.3	18.8	18.5	18.6	18.9	8.3
	none working, one or more retired	19.9	19.2	19.0	19.1	19.4	8.4
	none working and none retired	19.1	18.7	18.7	18.7	18.8	8.3
Annual gross income of the HRP and partner weighted quintiles	1st quintile (lowest)	19.5	19.1	18.8	18.9	19.1	8.4
	2nd quintile	19.4	18.6	18.5	18.6	18.8	8.4
	3rd quintile	19.4	18.8	18.9	18.9	19.1	8.5
	4th quintile	19.2	19.0	19.3	19.1	19.2	8.5
	5th quintile (highest)	18.7	18.6	18.8	18.6	18.7	8.6
Is anyone in the household at home during the day on a weekday?	No	18.7	18.5	18.5	18.5	18.6	8.6
	Yes	19.6	19.0	19.1	19.1	19.2	8.5
Under-occupying	Not under-occupying	19.6	19.1	19.2	19.2	19.3	8.5
	Under-occupying	18.7	18.3	18.3	18.3	18.4	8.4
Fuel Poverty Low Income High Cost indicator (LIHC)	Not in fuel poverty - LIHC	19.3	18.9	18.9	18.9	19.0	8.5
	In fuel poverty - LIHC	18.7	18.3	18.3	18.2	18.4	8.2

Base: All households in EFUS 2011 temperature sub-sample (n=823)

* Sample responses are very small and subject to large sampling errors

Table 10: Confidence intervals for mean room temperatures during the Heating Season (Oct – April, all days in month) by dwelling and household characteristics

Dwelling characteristic	Characteristic category	Sample size	Living Room	Zone 2
			95% CI mean temp (°C)	95% CI of mean temp (°C)
Dwelling type	End terrace	83	18.3, 19.5	18.3, 19.3
	Mid terrace	124	19.1, 19.9	18.7, 19.3
	Semi detached	244	18.6, 19.3	18.3, 18.9
	Detached	143	18.3, 19	18.2, 18.8
	Bungalow	101	18.9, 19.8	18.4, 19.3
	Flat	128	19.5, 20.5	18.7, 19.8
Dwelling type	House or bungalow	695	18.9, 19.2	18.5, 18.9
	Flat	128	19.5, 20.5	18.7, 19.8
Dwelling Age	Pre 1919	127	17.9, 18.7	17.6, 18.4
	1919-1944	127	18.7, 19.6	18.3, 19.1
	1945-1964	209	19.2, 19.8	18.6, 19.2
	1965-1974	138	18.9, 19.7	18.5, 19.3
	1975-1980	68	19.4, 20.8	19, 20.3
	1981-1990	79	19, 20	18.7, 19.5
	Post 1990	75	18.7, 19.7	18.7, 19.5
Useable floor area	< 50 m ²	89	19.5, 20.6	18.9, 20
	50 to 69 m ²	197	19, 19.8	18.5, 19.3
	70 to 89 m ²	213	18.7, 19.4	18.4, 19
	90 to 109 m ²	119	19, 19.8	18.5, 19.2
	110 to 139 m ²	95	18.4, 19.2	18.3, 19
	≥140 m ²	110	18.2, 19.1	18, 18.8
Region - EHS order	North East	57	18.4, 19.6	17.8, 19
	North West	130	18.3, 19.1	18, 18.8
	Yorkshire and the Humber	106	18.3, 19.2	17.7, 18.7
	East Midlands	79	19, 19.9	18.2, 19.1
	West Midlands	71	18.4, 19.6	17.9, 19
	East	112	19.1, 19.9	18.7, 19.5
	London	62	19.1, 20.6	19.1, 20.2
	South East	125	19, 19.8	18.8, 19.5
	South West	81	18.6, 19.6	18.1, 19
Urban or rural location?	Urban	722	19.1, 19.4	18.7, 19
	Rural	101	18.4, 19.4	17.8, 18.6
Type of heating system	Central Heating	754	19, 19.4	18.7, 19
	Non-Central Heating	69	18.8, 20.2	17.8, 19
Main fuel	Mains gas	687	18.9, 19.3	18.6, 19
	Electricity	66	18.8, 20.1	17.8, 19.1
	Other (bottled/bulk gas, solid, oil, communal)	70	18.9, 20.5	18.3, 19.8
Are the walls of the dwelling insulated?	Insulated	383	19.2, 19.6	18.7, 19.2
	Not insulated	440	18.8, 19.3	18.5, 18.9
Loft insulation	<50mm	48	17.8, 19.5	18, 19.5
	50-149mm	335	18.8, 19.4	18.5, 19
	150+ mm	355	18.9, 19.4	18.5, 18.9
Is dwelling fully double glazed?	Yes	639	19.2, 19.6	18.8, 19.1
	No	184	18.2, 19	18, 18.7
Dwelling insulation	All 3 insulation measures	139	18.7, 19.5	18.3, 19.1
	2 insulation measures	246	19.2, 19.8	18.6, 19.2
	1 insulation measure	265	19, 19.5	18.6, 19.1
	No insulation measures	88	17.3, 18.5	17.6, 18.6
Energy efficiency (SAP09) rating	less than 30	20*	16.7, 19.2	16.8, 18.6
	30 to 50	192	18.4, 19.2	18, 18.8
	51 to 70	545	19.1, 19.5	18.7, 19.1
	more than 70	66	19.4, 20.4	19, 20.1

Table 10 continued: Confidence intervals for mean room temperatures during the Heating Season (Oct – April, all days in month) by dwelling and household characteristics

Household characteristic	Characteristic category	Sample size	Living Room	Zone 2
			95% CI mean temp (°C)	95% CI of mean temp (°C)
Tenure	Owner Occupied	524	18.7, 19.2	18.5, 18.8
	Private rented	64	18.6, 19.8	18, 19.2
	Local Authority	128	19.6, 20.8	18.8, 20
	RSL	107	19.5, 20.4	18.9, 19.8
Household size	1	237	18.6, 19.3	18, 18.8
	2	303	19, 19.6	18.7, 19.1
	3	123	19, 19.8	18.7, 19.3
	4	114	18.7, 19.6	18.6, 19.3
	5 or more	46	18.6, 19.9	18.4, 19.6
Pensioner Present?	At least one person of pensionable age	337	19.4, 20	18.8, 19.3
	No persons of pensionable age	486	18.7, 19.1	18.5, 18.9
Children Present?	At least one child	222	18.9, 19.5	18.8, 19.3
	No children	601	19, 19.4	18.5, 18.9
Age of HRP	16 - 34	70	18.5, 19.7	18.5, 19.5
	35 - 44	125	18.6, 19.3	18.3, 19.1
	45 - 54	187	18.5, 19.1	18.2, 18.8
	55 - 64	181	18.6, 19.4	18.3, 18.9
	65 - 74	171	19.3, 20	18.6, 19.3
	75 or more	89	19.8, 20.9	19, 20.2
Employment status of HRP and partner combined	1 or more work full time	373	18.7, 19.2	18.5, 18.9
	1 or more work part time	71	18.7, 19.7	18.1, 19.1
	none working, one or more retired	283	19.5, 20.1	18.8, 19.4
	none working and none retired	96	18.5, 19.6	18.1, 19.2
Annual gross income of the HRP and partner weighted quintiles	1st quintile (lowest)	185	19.1, 19.9	18.5, 19.3
	2nd quintile	192	18.9, 19.7	18.2, 18.9
	3rd quintile	158	19, 19.7	18.5, 19.2
	4th quintile	155	18.8, 19.5	18.8, 19.4
	5th quintile (highest)	133	18.3, 19.1	18.2, 18.9
Is anyone in the household at home during the day on a weekday?	No	285	18.4, 18.9	18.2, 18.7
	Yes	538	19.4, 19.8	18.8, 19.2
Under-occupying?	Not under-occupying	524	19.3, 19.7	18.9, 19.3
	Under-occupying	299	18.4, 18.9	18, 18.5
In Fuel Poverty? LIHC definition	Not in fuel poverty	741	19.1, 19.4	18.7, 19
	In fuel poverty	82	18.1, 19.2	17.7, 18.7

Base: All households in EFUS 2011 temperature sub-sample (n=823)

Further investigation into the influence of different levels of control on mean heating season room temperatures in centrally heated households indicates that there is no statistical significant difference in mean heating season temperatures in either the living room or zone 2 (Table 11).

Table 11: Mean heating season room temperatures during the heating season for centrally heated households with differing level of control

		N	Living room		Zone 2	
			Mean room temperature °C	95% CI of mean room temperature °C	Mean room temperature °C	95% CI of mean room temperature °C
Do you have a working thermostat on the wall?	Yes	568	19.2	19.0, 19.4	18.8	18.6, 19.0
	No	183	19.3	18.8, 19.6	19.0	18.5, 19.3
Does household use timer for central heating control?	Yes	355	19.1	18.9, 19.3	18.9	18.6, 19.0
	No	213	19.3	18.9, 19.6	18.8	18.4, 19.1

Base: All households with a working thermostat or a central heating timer in EFUS 2011 temperature sample

3.5 Summary of temperatures achieved during extreme external conditions

Analysis of the average external temperatures for the months under consideration in this report show that the coldest days over most of the country were a period at the end of January 2011 and a period at the beginning of March 2011¹⁰. Table 12 shows the mean temperatures measured in each of the rooms for the subset of dwellings (9.8 million) for which three days in January were the coldest prolonged conditions experienced, along with the standard deviation and 95% confidence intervals. Also shown for comparison is the mean and 95% confidence intervals of the heating season temperatures for the same subset of dwellings. By comparing the confidence intervals it can be seen that for all rooms, the mean temperatures during the cold period are significantly lower than the mean heating season temperature.

Table 12: Mean room temperatures achieved during cold conditions on 29-31 January 2011 and comparison with the heating season average

	Mean temperature °C (3 day mean, n=373)	95% Confidence Intervals	Mean heating season temperature °C (n=373)	95% Confidence Intervals
External	-5.5	-5.6, -5.2	8.3	8.2, 8.4
Living room	17.8	17.4, 18.2	19.0	18.7, 19.3
Hallway	16.7	16.3, 17.0	18.4	18.1, 18.6
Bedroom	17.0	16.6, 17.4	18.6	18.3, 18.8
Zone 2	16.9	16.5, 17.2	18.5	18.2, 18.7
Dwelling	17.2	16.8, 17.5	18.7	18.4, 18.8

Base: Households in EFUS 2011 temperature sample for which three days in January 2011 were the coldest prolonged conditions experienced

¹⁰ Almost the entire month of December in 2010 saw temperatures considerably below the 1971-2000 average, but there were very few temperature loggers installed at this time.

A further subset of dwellings (7.2 million) experienced their coldest conditions during the first week of March and the results for these dwellings are shown in Table 13. The mean temperatures recorded during this cold period are statistically significantly lower for the hallway, but not for the living room or bedroom, compared to the mean temperature for the entire heating season for the same subset of dwellings. Further investigation of the external and room temperatures for the period preceding the cold snaps is required to explain these findings.

Table 13: Mean room temperatures achieved during cold conditions on 3,5,7 and 8 March 2011

	Mean temperature °C (4 day mean, n=239)	95% Confidence Intervals	Mean heating season temperature °C (n=239)	95% Confidence Intervals
External	-3.3	-3.4, -3	8.9	8.7, 8.9
Living room	19.0	18.6, 19.3	19.6	19.2, 19.9
Hallway	18.7	18.3, 19	19.4	19.1, 19.7
Bedroom	18.7	18.3, 19	19.3	19, 19.6
Zone 2	18.7	18.3, 19	19.4	19, 19.6
Dwelling	18.8	18.5, 19	19.4	19.1, 19.7

Base: Households in EFUS 2011 temperature sample for which the first week in March 2011 were the coldest prolonged conditions experienced

There was a period of extreme hot conditions that occurred across most of the country on the 26-27 June 2011. Table 14 shows the mean (and the 95% confidence intervals) of the temperatures recorded in the dwellings during these 2 days as well as the 'summer average' temperature (calculated as the mean temperature in June, July and August). It can be seen that the temperatures recorded in the dwellings during the hot spell are significantly higher than the summer average.

Table 14: Mean room temperatures achieved during hot conditions on 26-27 June 2011

	Mean temperature °C (2 day mean, n=639)	95% Confidence Intervals	Mean 'Summer'* temperature	95% Confidence Intervals
External	29.1	28.9, 29.2	9.2	15.1, 15.2
Living room	23.9	23.7, 24	3.0	21.1, 21.4
Hallway	24.1	23.9, 24.2	3.1	21, 21.3
Bedroom	25.0	24.8, 25.1	2.7	21.4, 21.7
Zone 2	24.5	24.3, 24.6	2.9	21.3, 21.5
Dwelling	24.3	24.1, 24.4	2.9	21.2, 21.5

Base: Households in EFUS 2011 temperature sample for which the 26-27 June 2011 were the hottest conditions experienced

* calculated as the mean temperature in June, July and August

4 Conclusions

The results of the analysis of mean room temperatures collected over a period of 12 months from a subset of 823 dwellings of the EFUS 2011 are presented in this report. Monthly mean temperatures in the living room, hallway and bedroom have been calculated from raw data files containing temperatures logged at 20-minute intervals. From these, a 'zone 2' temperature has been calculated from the mean of the hallway and bedroom temperatures, and a 'dwelling' temperature has been calculated from the mean of the living room, hallway and bedroom temperatures. The predominant focus of this report has been the heating season months, and so for this purpose the mean temperatures during the heating season (October to April inclusive) for each room have been calculated. Relationships between the temperatures in each room, between zone 1 and zone 2, between weekdays and weekend days and the variation in mean heating season temperatures by various dwelling and household characteristics have then been investigated. Finally, the room temperatures recorded during a cold and hot 'extreme' weather event have been examined and compared to the average recorded for the whole heating season (cold weather event) and the summer months (hot weather event).

The main findings of the analysis are:

- § Mean monthly temperatures for the whole dwelling range from 18.1°C in December to 21.5°C in July and August.
- § The mean monthly temperatures calculated from the EFUS data for the whole stock are between 0.1°C and 0.8°C higher for the months of heating than those calculated by SAP for a typical semi-detached house (using 2011 mean external temperatures), although the difference was negligible for November, December and January as the SAP values are within the bounds of the sampling error for the EFUS data.
- § On an individual room level, mean monthly temperatures in the living room are higher than in either the hallway or bedroom for the months of October through to March; while for the remaining months, mean monthly temperatures in the bedroom are typically the highest.
- § In the winter months, mean monthly temperatures in zone 1 are approximately 0.6°C higher than in zone 2. During the summer months the difference in temperature between zone 1 and zone 2 is not significant. In SAP, the calculated zone 1/zone 2 difference is between 0.7°C and 1°C higher than the mean difference determined from the EFUS data for the winter months.
- § In approximately 30% of households the mean monthly temperatures in zone 1 are lower than those in zone 2 (although the majority of households have zone 1 warmer than zone 2).
- § The mean room temperatures recorded during the heating season (October to April) are 19.3°C for the living room, 18.8°C for the hallway and 18.9°C for the bedroom, from which a mean temperature of 18.8°C for zone 2 and 19.0°C for the dwelling has been derived.
- § Approximately 65% of households maintain their living rooms and zone 2 areas within the range of 18-22°C during the heating season. However 26% of households maintain their living rooms at temperatures below 18°C, while a further 7% of households heat their living rooms to temperatures at or above 22°C.

- § There are no statistically significant differences between weekday and weekend day mean heating season temperatures in the living room, bedroom, zone 2 or the dwelling as a whole.
- § The variations in mean heating season temperatures for different dwelling and household characteristics have been investigated. Dwellings that were fully double glazed, those with someone in during the day during a weekday, and those in which the occupants are not under-occupying have both living room and zone 2 mean heating season temperatures that are significantly higher than their alternative category.
- § Other significant differences that could be seen include dwellings built pre-1919 having lower mean heating season temperatures in both zones than dwellings built between 1945 and 1990; dwellings with a floor area <math><50\text{m}^2</math> having higher mean heating season temperatures in both zones than the largest dwellings with floor areas >math>>140\text{m}^2</math>; owner-occupied dwellings having lower living room and zone 2 mean heating season temperatures than local authority or RSL dwellings and dwellings in which the HRP is older than 75 years having higher living room and zone 2 mean heating season temperatures than dwellings with the HRP aged between 45-64 years.
- § Some groups of dwellings have significant differences in the mean heating season temperatures in one or other of the zones but not both:
 - Flats are seen to have higher living room mean heating season temperatures than detached or semi-detached dwellings but no difference is seen between dwelling types for zone 2 mean heating season temperatures.
 - Dwellings in rural locations tend to have lower zone 2 mean heating season temperatures than those in urban areas and dwellings in London tend to have higher zone 2 mean heating season temperatures than dwellings in the North West and Yorkshire and Humber regions but no differences are seen between the living room mean heating season temperatures for either characteristic.
 - Dwellings with no insulation measures have lower living room mean heating season temperatures than dwellings with at least one or more insulation measure, but no differences are seen in the zone 2 mean heating season temperatures for this characteristic.
 - Households with a pensioner living in the dwelling typically have higher living room mean heating season temperatures than households without a pensioner present; similarly households with one or more persons retired have higher living room mean heating season temperatures than households with one or more persons working full time. No differences in the mean heating season temperatures in zone 2 are seen for any of these groups.
- § For some groups there are no significant (or very small) differences in mean heating season temperatures: these are centrally heated versus non-centrally heated dwellings, dwellings using different fuels for their main heating; cavity insulated walls versus non-insulated walls, differing levels of loft insulation, households of differing sizes, households with and without children present, households in all income quintiles and households in fuel poverty under the Low Income High Costs (LIHC) indicator.

- § The coldest days over most of the country were a period at the end of January 2011 and a period at the beginning of March 2011. Analysis of the EFUS data shows that temperatures collected during the January cold period are significantly lower than the average heating season temperature in all rooms. However the difference significance is not apparent for all rooms during the March period.
- § The hottest conditions occurred across most of the country on the 26-27 June 2011. Temperatures recorded in the dwellings during the hot spell are significantly higher than the summer average.

The key implications for the energy modelling methodologies of SAP/BREDEM are as follows:

- § The typical difference in the zone 1/zone 2 mean temperature calculated in the models may be an over-estimate. The results from the temperature monitoring suggest that zone 2 temperatures may be closer to the zone 1 temperatures than currently predicted by these models. Additional work in this area, however, required to fully understand what might cause these differences.
- § The difference between weekday/weekend day mean dwelling temperatures currently implemented in SAP may not be necessary. This supports the results presented in the Main Heating report, in that householders report little change in the number of hours that their heating is on between weekdays and weekends.
- § The monthly mean dwelling temperatures recorded during the EFUS 2011 match relatively well with the values calculated in SAP. The EFUS provides evidence for higher temperatures in summer compared to those used in SAP (due to a cap set in SAP) which, although not relevant to heating costs, may have implications for cooling costs in the future.

Glossary

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 householder responses to q167/168/169/170 in the EFUS 2011 Interview survey for new households and from variables obtained from the EHS Interview survey for households that had not changed since the earlier EHS interview.
Annual gross income of the HRP and partner weighted quintiles:	This is the annual income of the Household Reference Person and (any) partner. This includes income from private sources (regular employment, self-employment, government schemes, occupational pensions, private pensions and other private income), state benefits/allowances and tax credits, as collected on the EHS survey (this includes housing benefit/Local Housing Allowance but excludes council tax benefit and Support for Mortgage Interest) and interest from savings. It is a gross measure i.e. income before Income Tax or National Insurance deductions.
Children Present:	Anyone in the household who is 16 years old or younger. Derived from householder responses to q167/168/169/170 in the EFUS 2011 Interview survey for new households and from variables obtained from the EHS Interview survey for household that had not changed since the EHS interview.
Dwelling insulation:	The number of insulation measures where positive responses for 'Fully double glazed', 'Insulated walls' and having loft insulation greater than 200mm count as insulation measures.
Dwelling type:	Classification of dwelling on the basis of the surveyors' inspections during the EHS physical survey.
Employment status of HRP and Partner combined:	Information on employment status was not re-collected as part of the EFUS and is as reported in the EHS interview survey (and some households may have changed status in the period between the two interviews).
Fuel Poverty – LIHC definition:	<p>Under the Low Income High Cost definition a household is considered to be fuel poor where:</p> <ul style="list-style-type: none">• 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. <p>Please refer to the following documents for more information. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66570/6406-fuel-poverty-changing-the-framework-for-</p>

measureme.pdf

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/226988/fuel_poverty_stats_methodology_handbook_2013.pdf

Fully double glazed:	Derived from the 'dblglaz4' variable as measured by surveyors in the EHS physical survey. Fully double glazed is 'entire house double glazed'. Not fully double glazed is anything less than fully double glazed.
Household size:	Number of persons in the household, banded into 5 groups, derived from the 'hhsizex' variable from the EHS Interview survey.
In during the day:	See the EHS interview documentation for full details of occupancy questions asked as part of the EHS (question 'Hmwtht'). A household has been classified as being 'in during a weekday' if they indicate being generally in the house on weekdays during the winter, for any period between 9am and 5pm. It should be noted that this information was not re-collected as part of the EFUS, and some households occupancy patterns may have changed in the interval between the two interview surveys.
Insulated walls:	Derived from the 'wallinsx' variable as measured by surveyors in the EHS physical survey. 'Insulated' are 'cavity with insulation'; 'Not insulated' includes 'cavity without insulation' and 'other' wall types.
Loft insulation:	Banded variable of 'loftinsx', the level of loft insulation recorded by surveyors in the EHS physical survey.
Main fuel:	As determined 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.
Pensioner Present:	Anyone in the household who is 65 or over (male) or 60 or over (female). Derived from householder responses to q167/168/169/170 in the EFUS 2011 Interview survey for new households and from variables obtained from the EHS Interview survey for households that had not changed since the EHS interview.
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).
Tenure:	Derived from householder responses to q01 in the EFUS 2011 Interview

survey.

- Type of heating: Central heating or non-central heating. Determined from householder responses to Q06 in EFUS 2011 interview survey. Non-central heating includes storage radiators, gas fires, electric heaters, coal/wood/smokeless fuel fires or stoves and other.
- 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: <http://www.decc.gov.uk/assets/decc/Statistics/fuelpoverty/614-fuel-poverty-methodologyhandbook.pdf>
- Useable floor area: The total usable internal floor area of the dwelling as measured by the surveyor in the EHS physical survey, 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 5 categories.

Appendix A: Summary statistics for monthly mean temperature data

1. External temperature

a. All days in month mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	6.6	6.5	.8	.6	8.4	6.2	7.1
Mar 2011	6.7	6.7	.7	1.6	11.8	6.3	7.1
Apr 2011	11.9	11.9	1.0	6.1	14.2	11.4	12.2
May 2011	12.4	12.4	1.1	5.5	14.7	11.9	13.1
Jun 2011	14.3	14.3	1.0	7.3	16.4	13.8	14.9
Jul 2011	15.4	15.5	.9	9.5	17.9	15.0	15.9
Aug 2011	15.6	15.6	1.1	9.2	17.7	15.0	16.2
Sep 2011	15.1	15.1	.9	9.9	17.1	14.7	15.7
Oct 2011	12.6	12.6	.9	6.1	14.6	12.2	13.1
Nov 2011	9.7	9.6	.8	4.4	12.6	9.2	10.2
Dec 2011	6.2	6.1	1.0	-.3	11.0	5.6	7.0
Jan 2012	5.6	5.5	1.0	-.6	11.0	5.0	6.3

b. Weekdays only in month mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	6.5	6.5	.8	.7	8.5	6.0	7.1
Mar 2011	6.9	6.8	.7	2.0	11.8	6.4	7.3
Apr 2011	11.7	11.7	1.0	5.9	13.8	11.2	12.1
May 2011	12.2	12.1	1.1	5.5	14.4	11.7	12.8
Jun 2011	14.3	14.3	1.0	7.4	16.5	13.7	14.9
Jul 2011	15.4	15.4	.9	9.4	17.5	15.1	15.9
Aug 2011	15.6	15.7	1.1	9.5	17.8	15.0	16.1
Sep 2011	15.1	15.1	1.0	9.9	17.2	14.7	15.8
Oct 2011	12.2	12.2	1.0	5.5	14.3	11.7	12.8
Nov 2011	9.8	9.6	.8	4.4	12.6	9.3	10.3
Dec 2011	6.3	6.1	1.0	-.3	11.0	5.6	7.1
Jan 2012	5.7	5.5	1.0	-.6	11.0	5.1	6.3

c. Weekend days only in month mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	6.8	6.9	1.0	.3	8.7	6.4	7.6
Mar 2011	6.3	6.2	.7	.3	8.7	5.8	6.7
Apr 2011	12.3	12.3	1.1	6.4	15.6	11.6	12.8
May 2011	13.1	13.1	1.1	5.5	15.6	12.6	13.9
Jun 2011	14.3	14.2	1.0	7.0	16.3	13.8	14.8
Jul 2011	15.5	15.6	1.0	9.8	18.7	15.0	16.0
Aug 2011	15.5	15.5	1.1	8.5	17.8	14.8	16.1
Sep 2011	15.1	15.1	.9	9.9	16.9	14.7	15.6
Oct 2011	13.5	13.5	.8	7.4	15.7	13.1	13.9
Nov 2011	9.5	9.4	1.0	4.4	12.4	8.9	10.2
Dec 2011	6.1	5.9	.9	-.1	11.0	5.4	6.7
Jan 2012	5.4	5.3	1.1	-.7	11.0	4.8	6.1

2. Dwelling temperatures

a. All days in month

Living room mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	19.0	19.2	2.4	9.7	27.1	17.4	20.6
Mar 2011	19.0	19.1	2.4	11.1	27.0	17.4	20.5
Apr 2011	20.0	20.1	1.9	14.3	27.9	18.8	21.3
May 2011	20.0	20.1	1.9	14.7	28.1	18.8	21.2
Jun 2011	20.9	20.9	1.7	15.8	28.1	19.7	21.9
Jul 2011	21.4	21.4	1.6	17.0	29.7	20.4	22.3
Aug 2011	21.5	21.5	1.5	17.2	28.5	20.5	22.5
Sep 2011	20.8	20.8	1.6	16.0	28.0	19.7	21.8
Oct 2011	20.1	20.3	1.8	14.4	27.8	18.9	21.3
Nov 2011	19.3	19.5	2.1	12.9	27.7	17.9	20.7
Dec 2011	18.6	18.8	2.6	9.9	27.5	16.9	20.3
Jan 2012	18.7	18.9	2.6	9.6	27.5	17.1	20.4

Hallway mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	18.5	18.6	2.4	8.8	27.3	17.1	20.0
Mar 2011	18.6	18.6	2.3	10.6	27.3	17.0	20.1
Apr 2011	19.7	19.7	1.8	14.1	28.0	18.6	20.9
May 2011	19.7	19.7	1.8	14.7	28.2	18.4	20.8
Jun 2011	20.7	20.7	1.6	15.9	28.1	19.7	21.8
Jul 2011	21.3	21.3	1.4	16.8	28.5	20.3	22.2
Aug 2011	21.3	21.3	1.4	16.8	27.8	20.4	22.3
Sep 2011	20.5	20.5	1.5	15.8	27.3	19.5	21.5
Oct 2011	19.8	19.7	1.7	13.7	27.8	18.7	21.0
Nov 2011	18.9	19.0	2.1	12.0	28.4	17.6	20.2
Dec 2011	18.0	18.2	2.6	9.5	29.4	16.5	19.7
Jan 2012	18.2	18.4	2.6	9.6	29.4	16.7	19.9

Bedroom mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	18.5	18.5	2.4	10.4	27.4	17.0	19.9
Mar 2011	18.8	18.9	2.3	11.6	28.0	17.4	20.2
Apr 2011	20.2	20.1	1.7	16.0	28.5	19.0	21.3
May 2011	20.1	20.1	1.7	15.4	28.0	18.9	21.1
Jun 2011	21.2	21.2	1.4	17.1	27.9	20.2	22.1
Jul 2011	21.7	21.7	1.3	18.2	28.5	20.8	22.6
Aug 2011	21.6	21.6	1.4	17.7	28.5	20.7	22.5
Sep 2011	20.7	20.7	1.5	15.8	28.0	19.7	21.7
Oct 2011	19.8	19.8	1.7	14.0	27.6	18.7	21.0
Nov 2011	18.8	18.8	2.1	11.7	27.1	17.5	20.1
Dec 2011	17.8	18.0	2.6	9.0	27.8	16.3	19.5
Jan 2012	18.1	18.2	2.6	9.0	28.0	16.5	19.7

Zone 2 mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	18.5	18.6	2.3	9.7	26.8	17.3	19.9
Mar 2011	18.7	18.7	2.2	11.5	26.8	17.4	20.0
Apr 2011	20.0	20.0	1.7	14.1	27.8	18.9	21.0
May 2011	19.9	19.9	1.7	14.7	28.1	18.8	21.0
Jun 2011	21.0	21.0	1.4	16.2	28.0	20.0	21.9
Jul 2011	21.5	21.5	1.3	17.3	28.5	20.6	22.3
Aug 2011	21.5	21.5	1.3	17.4	28.2	20.7	22.3
Sep 2011	20.6	20.7	1.4	16.1	27.7	19.6	21.5
Oct 2011	19.8	19.8	1.6	13.8	27.4	18.8	20.9
Nov 2011	18.8	18.9	2.0	11.9	27.1	17.7	20.0
Dec 2011	17.9	18.1	2.5	9.5	27.8	16.5	19.5
Jan 2012	18.1	18.3	2.5	9.4	27.9	16.7	19.7

Dwelling mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	18.7	18.7	2.2	9.8	26.9	17.3	20.1
Mar 2011	18.8	18.9	2.1	11.8	26.9	17.5	20.1
Apr 2011	20.0	20.0	1.7	14.3	27.9	18.9	21.1
May 2011	19.9	19.9	1.7	14.7	28.1	18.8	20.9
Jun 2011	20.9	21.0	1.4	16.2	28.0	20.0	21.9
Jul 2011	21.5	21.5	1.3	17.4	28.5	20.6	22.3
Aug 2011	21.5	21.5	1.3	17.4	28.3	20.5	22.3
Sep 2011	20.7	20.7	1.4	16.2	27.8	19.7	21.6
Oct 2011	19.9	20.0	1.6	14.0	27.5	18.8	20.9
Nov 2011	19.0	19.1	1.9	12.3	27.3	17.7	20.2
Dec 2011	18.1	18.2	2.4	9.7	27.1	16.7	19.7
Jan 2012	18.3	18.4	2.4	9.5	27.2	17.0	19.8

b. Weekdays only in month

Living room mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	18.9	19.1	2.5	9.4	27.0	17.3	20.5
Mar 2011	19.0	19.1	2.4	10.9	27.0	17.4	20.4
Apr 2011	19.9	20.0	1.9	14.1	27.7	18.6	21.2
May 2011	19.9	20.0	1.9	14.7	28.2	18.7	21.1
Jun 2011	20.9	21.0	1.7	16.0	28.2	19.8	21.9
Jul 2011	21.4	21.5	1.6	17.0	29.9	20.5	22.4
Aug 2011	21.5	21.6	1.5	17.1	28.5	20.5	22.5
Sep 2011	20.7	20.7	1.6	15.9	28.0	19.6	21.7
Oct 2011	20.1	20.2	1.8	14.5	27.7	18.8	21.2
Nov 2011	19.3	19.4	2.1	12.8	27.6	17.8	20.6
Dec 2011	18.5	18.8	2.6	9.5	27.5	16.8	20.3
Jan 2012	18.6	18.9	2.6	9.5	27.5	17.0	20.3

Hallway mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	18.4	18.6	2.5	8.8	27.3	16.9	19.9
Mar 2011	18.6	18.6	2.3	10.7	27.3	17.0	20.1
Apr 2011	19.6	19.5	1.8	14.0	27.7	18.4	20.8
May 2011	19.7	19.6	1.8	14.7	28.1	18.4	20.8
Jun 2011	20.8	20.7	1.6	16.0	28.2	19.7	21.8
Jul 2011	21.3	21.3	1.4	16.8	28.4	20.4	22.2
Aug 2011	21.4	21.4	1.4	16.8	27.9	20.4	22.3
Sep 2011	20.5	20.5	1.5	15.8	27.2	19.4	21.4
Oct 2011	19.7	19.7	1.7	13.8	27.8	18.6	20.9
Nov 2011	18.8	18.9	2.1	12.0	28.3	17.6	20.2
Dec 2011	18.0	18.3	2.6	9.7	29.5	16.4	19.7
Jan 2012	18.1	18.3	2.6	9.6	29.4	16.6	19.8

Bedroom mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	18.4	18.5	2.4	10.3	27.4	17.0	19.8
Mar 2011	18.8	18.9	2.3	11.6	27.9	17.4	20.3
Apr 2011	20.0	20.0	1.7	15.8	28.3	18.9	21.1
May 2011	20.0	20.0	1.7	15.6	28.0	18.8	21.0
Jun 2011	21.3	21.3	1.5	17.2	27.9	20.3	22.2
Jul 2011	21.8	21.7	1.3	18.2	28.4	20.8	22.6
Aug 2011	21.7	21.7	1.4	17.8	28.5	20.7	22.6
Sep 2011	20.7	20.7	1.5	15.8	28.0	19.6	21.6
Oct 2011	19.7	19.7	1.7	14.0	27.5	18.7	20.9
Nov 2011	18.7	18.8	2.1	11.7	27.1	17.4	20.1
Dec 2011	17.8	17.9	2.6	9.1	27.8	16.3	19.5
Jan 2012	18.0	18.2	2.6	9.1	28.1	16.5	19.7

Zone 2 mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	18.4	18.5	2.3	9.5	26.7	17.1	19.8
Mar 2011	18.7	18.7	2.2	11.6	26.8	17.4	20.0
Apr 2011	19.8	19.8	1.7	14.0	27.6	18.7	20.8
May 2011	19.8	19.8	1.7	14.7	28.1	18.7	20.9
Jun 2011	21.0	21.1	1.4	16.2	28.1	20.1	21.9
Jul 2011	21.6	21.5	1.3	17.3	28.4	20.7	22.3
Aug 2011	21.5	21.5	1.3	17.4	28.2	20.7	22.4
Sep 2011	20.6	20.6	1.4	16.1	27.6	19.6	21.4
Oct 2011	19.7	19.7	1.7	13.9	27.3	18.7	20.8
Nov 2011	18.8	18.8	2.0	11.9	27.0	17.6	20.0
Dec 2011	17.9	18.1	2.5	9.1	27.8	16.5	19.5
Jan 2012	18.1	18.2	2.5	9.3	27.9	16.6	19.7

Dwelling mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	18.6	18.6	2.2	9.5	26.8	17.2	19.9
Mar 2011	18.8	18.9	2.1	11.9	26.8	17.4	20.1
Apr 2011	19.8	19.8	1.7	14.2	27.6	18.7	20.9
May 2011	19.9	19.9	1.7	14.7	28.1	18.7	20.9
Jun 2011	21.0	21.1	1.4	16.2	28.1	20.1	21.9
Jul 2011	21.5	21.5	1.3	17.4	28.5	20.6	22.3
Aug 2011	21.5	21.6	1.3	17.4	28.3	20.6	22.4
Sep 2011	20.6	20.7	1.4	16.1	27.7	19.6	21.5
Oct 2011	19.8	19.9	1.6	14.1	27.4	18.7	20.8
Nov 2011	19.0	19.1	1.9	12.2	27.2	17.7	20.1
Dec 2011	18.1	18.3	2.4	9.3	27.1	16.7	19.6
Jan 2012	18.3	18.4	2.4	9.4	27.2	16.8	19.7

c. Weekend days only in month

Living room mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	19.3	19.4	2.4	10.4	27.1	17.8	20.9
Mar 2011	19.0	19.2	2.4	10.5	27.3	17.5	20.6
Apr 2011	20.3	20.4	1.9	14.6	28.5	19.1	21.5
May 2011	20.1	20.2	1.9	14.8	28.1	18.9	21.3
Jun 2011	20.7	20.8	1.7	15.5	28.0	19.6	21.7
Jul 2011	21.4	21.4	1.6	17.0	29.5	20.4	22.3
Aug 2011	21.4	21.4	1.5	17.1	28.3	20.4	22.3
Sep 2011	20.9	20.9	1.6	16.2	28.1	19.9	22.0
Oct 2011	20.3	20.4	1.8	14.1	28.0	19.1	21.4
Nov 2011	19.5	19.7	2.1	13.3	27.9	18.1	20.8
Dec 2011	18.6	18.8	2.6	10.7	27.4	17.0	20.4
Jan 2012	18.8	19.1	2.6	9.9	27.6	17.3	20.5

Hallway mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	18.8	18.9	2.4	8.9	27.4	17.3	20.3
Mar 2011	18.6	18.7	2.4	10.4	27.2	17.0	20.1
Apr 2011	20.0	20.0	1.8	14.4	28.6	18.9	21.2
May 2011	19.8	19.8	1.8	14.9	28.2	18.6	21.0
Jun 2011	20.6	20.5	1.6	15.8	27.9	19.6	21.6
Jul 2011	21.3	21.3	1.4	16.8	28.6	20.3	22.1
Aug 2011	21.2	21.2	1.4	16.7	27.6	20.3	22.2
Sep 2011	20.7	20.7	1.5	15.8	27.5	19.6	21.7
Oct 2011	19.9	19.9	1.7	13.6	27.8	18.8	21.1
Nov 2011	19.0	19.2	2.1	12.2	28.7	17.7	20.3
Dec 2011	18.0	18.2	2.6	9.0	29.3	16.6	19.8
Jan 2012	18.3	18.5	2.6	9.6	29.3	16.8	19.8

Bedroom mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	18.7	18.8	2.3	10.5	27.6	17.4	20.2
Mar 2011	18.8	18.8	2.4	11.3	28.2	17.3	20.4
Apr 2011	20.6	20.6	1.7	16.2	29.0	19.4	21.7
May 2011	20.2	20.2	1.7	14.8	27.9	19.0	21.2
Jun 2011	21.0	21.0	1.5	16.7	27.7	20.0	21.9
Jul 2011	21.7	21.7	1.4	18.0	28.5	20.8	22.5
Aug 2011	21.5	21.4	1.4	17.3	28.3	20.5	22.3
Sep 2011	20.9	20.9	1.5	15.7	28.0	19.9	21.9
Oct 2011	20.1	20.1	1.7	13.9	27.8	19.0	21.2
Nov 2011	18.9	19.0	2.1	11.8	27.3	17.6	20.3
Dec 2011	17.8	18.0	2.7	8.3	27.8	16.3	19.6
Jan 2012	18.2	18.4	2.6	8.8	28.0	16.7	19.8

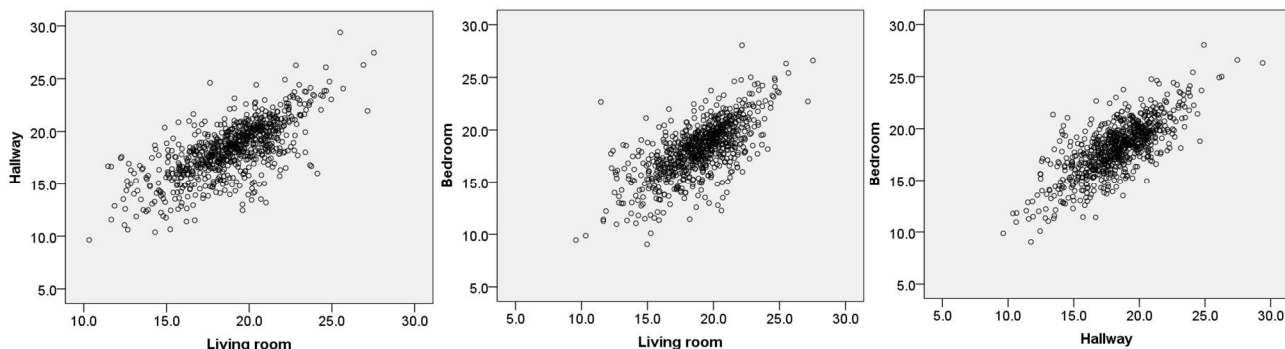
Zone 2 mean temperature (°C)

	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	18.7	18.9	2.2	10.3	26.9	17.6	20.0
Mar 2011	18.7	18.8	2.2	11.2	26.9	17.3	20.0
Apr 2011	20.3	20.3	1.6	14.4	28.4	19.2	21.3
May 2011	20.0	20.0	1.7	14.9	28.1	18.9	21.1
Jun 2011	20.8	20.8	1.4	16.0	27.8	19.8	21.7
Jul 2011	21.5	21.5	1.3	17.3	28.5	20.6	22.3
Aug 2011	21.3	21.3	1.3	17.3	27.9	20.5	22.2
Sep 2011	20.8	20.9	1.4	16.2	27.8	19.8	21.7
Oct 2011	20.0	20.0	1.6	13.8	27.6	19.0	21.0
Nov 2011	19.0	19.1	2.0	12.0	27.3	17.8	20.2
Dec 2011	17.9	18.1	2.5	9.2	27.7	16.5	19.5
Jan 2012	18.2	18.4	2.5	9.8	27.8	16.8	19.8

Dwelling mean temperature (°C)

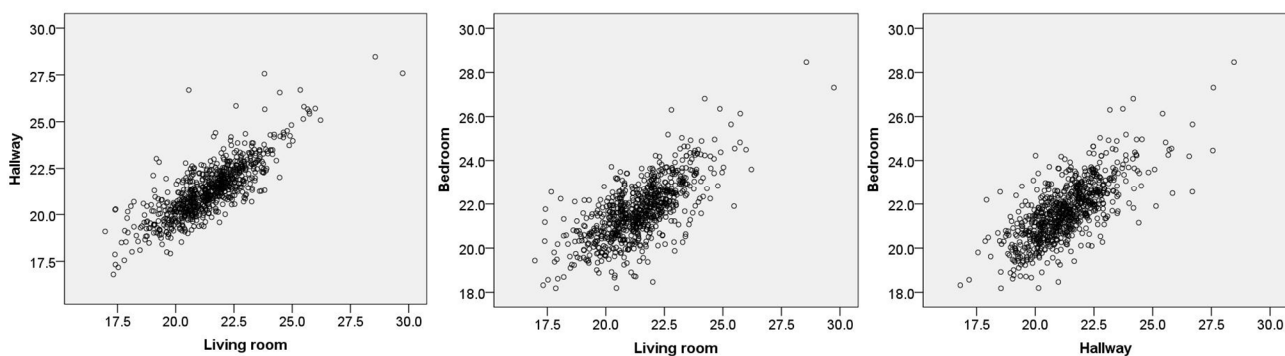
	Mean	Median	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 75
Feb 2011	18.9	19.0	2.1	10.4	27.0	17.6	20.3
Mar 2011	18.8	18.9	2.2	11.5	27.0	17.4	20.1
Apr 2011	20.3	20.3	1.6	14.6	28.4	19.2	21.4
May 2011	20.0	20.1	1.7	14.9	28.1	18.9	21.0
Jun 2011	20.8	20.8	1.5	16.0	27.9	19.8	21.7
Jul 2011	21.5	21.5	1.3	17.3	28.6	20.6	22.2
Aug 2011	21.3	21.4	1.4	17.3	28.1	20.4	22.2
Sep 2011	20.8	20.9	1.5	16.3	27.9	19.9	21.8
Oct 2011	20.1	20.1	1.6	13.9	27.7	19.0	21.1
Nov 2011	19.2	19.2	1.9	12.6	27.5	17.9	20.4
Dec 2011	18.1	18.3	2.4	9.7	27.0	16.7	19.7
Jan 2012	18.4	18.6	2.4	9.9	27.2	17.2	19.8

Scatter plot of mean room temperatures (°C) between rooms in January 2012



Base: All households in the EFUS 2011 temperature sample (n = 823)

Scatter plot of mean room temperatures (°C) between rooms in July 2011



Base: All households in the EFUS 2011 temperature sample (n = 823)

Correlation coefficients of mean room temperatures between rooms in January 2012

	Living Room	Hallway	Bedroom
Living room	1	0.699**	0.681**
Hallway		1	0.748**
Bedroom			1

Base: All households in the EFUS 2011 temperature sample. Unweighted sample (n=823).

** . Correlation is significant at the 0.01 level (2-tailed).

Correlation coefficients of mean room temperatures between rooms in July 2011

	Living Room	Hallway	Bedroom
Living room	1	0.807**	0.697**
Hallway		1	0.722**
Bedroom			1

Base: All households in the EFUS 2011 temperature sample. Unweighted sample (n=823).

** . Correlation is significant at the 0.01 level (2-tailed).