Carbon dioxide emissions: Northern Ireland's housing stock 2016

Published 14 November 2018

Table of Contents

This report is based on the findings of the House Condition Survey 2016 which is published on the Housing Executive's website:

https://www.nihe.gov.uk/house_condition_survey_main_report_2016.pdf

For further information about the carbon dioxide emissions report or the House Condition Survey contact:

The Research Unit
Northern Ireland Housing Executive
2 Adelaide Street
Belfast
BT2 8PB

Karly Greene (Lead Statistical Official)
Email: karly.greene@nihe.gov.uk
Tel: (028) 9598 2540

or

Jahnet Brown
Email: jahnet.brown@nihe.gov.uk
Tel: (028) 9598 2548

Introduction and key findings

Background

Under the Home Energy Conservation Act (1995), the Housing Executive is Northern Ireland's sole Home Energy Conservation Authority (HECA), and is mandated to produce an Annual Report on energy efficiency progress across all residential sectors (NIHE, 2017). Analysis of data from the Northern Ireland House Condition Survey 2011 showed that progress since 1996 was standing at 22.5% (progress was measured by calculating the reduction in energy consumption in occupied dwellings). Significant improvement" is defined as 34%, measured against the original statistics, published in April 1996.

The Housing Executive ran the most recent iteration of the House Condition Survey series in 2016, the main findings of which were published in May 2018[1]. The survey consisted of 2,023 full surveys, of which 1,942 were occupied. NIHE developed a weighting factor that was applied to the data for analysis which grossed these dwellings up to the national total of approximately 780,000. Vacant dwellings are a small proportion of the housing stock and are more variable in characteristics such as state of repair, modernisation and energy efficiency. The estimates from the survey for this group are therefore also more variable. For this reason, results in this report are presented for all dwellings and just for occupied dwellings and the headline metric for reporting of carbon dioxide emissions from the housing stock is that for occupied dwellings as it is assumed that vacant properties will not be heated or lit and therefore emissions from these dwellings will be negligible.

BRE was commissioned to use the house condition survey data to produce updated estimates of progress against HECA. This report presents a summary of the findings of that work. This report summarises the CO_2 emissions from the Northern Ireland housing stock in 2016, calculated in a manner consistent with HECA, and provides an updated time series back to 1996.

Key findings

As mentioned, in 2011, the improvement in energy efficiency; as measured by modelled standardised consumption, since 1996 was standing at 22.5% from the occupied pre-1996 housing stock. The improvement between 1996 and 2016 was 29.1%. (Table 1)

[1] https://touch.nihe.gov.uk/house_condition_survey_main_report_2016.pdf

Methodology

The analysis provides the CO_2 emissions from dwellings in Northern Ireland from the following activities:

- Space heating
- Water heating
- Lights and appliance use
- Cooking

The space and water heating emissions have been calculated using SAP (Standard Assessment Procedure) conventions. SAP is updated periodically and the version of SAP widely in use at the time of the 2016 survey was SAP 2012. To allow for time series comparisons the SAP version used for this carbon dioxide emissions analysis is SAP 2009. Similarly, lights and appliances and cooking emissions have been produced using the 2001 BRE Domestic Energy Model (BREDEM) routines despite the most current version of BREDEM being BREDEM 2012. The use of the SAP 2009 and BREDEM 2001 methodologies for analysing the 2016 dataset means that the findings can be compared to previous years.

The analysis considers only those dwellings built prior to 1996. This is achieved by selecting out those dwellings in the Northern Ireland House Condition Survey (NIHCS) data with a 'Construction Date' between categories 1 (pre 1919) and 6 (1981-1990), and those in category 7 (1991-2000) where the actual construction date is prior to 1996[2].

Other assumptions made within the modelling are that all post-1980 constructed cavity walls are insulated when calculating CO_2 emissions. In addition; and consistent with previous analysis, dwellings described as 'other vacants' are excluded from the analysis.

Figure 1 below shows which methodologies have been used for each survey year. It is important to recognise that the consumption estimates presented here do not necessarily reflect the actual consumption of these households. Rather this is the standardised consumption using the assumptions laid out in the SAP methodology. This methodology standardises certain aspects of the calculation; for example the thermostat set point temperature, the heating regimes and the external temperatures.

[2] As detailed in the 2011 HECA report, for the 2006 survey the actual construction date was not collected in the correct manner for it to be used for the purpose of selecting out pre-1996 dwellings and so in order for the correct number of dwellings to be included in the 2006 analysis we randomly selected a proportion of those in category 7. It has been assumed that the rate of construction was constant throughout that construction date band.

Figure 1: Methodology for HECA consumption and emissions, 1996-2016

	1996	2001	2006	2009	2011	2016
Space heating energy use	From the SAP 2009 model					
Water heating energy use	From the SAP 2009 model					
Lights and Appliance energy use	BREDEM 1996 algorithm	BREDEM 2001 algorithm				
Cooking energy use	BREDEM 2001 algorithm					
CO_2 emission factors	1996 SAP emissions	2001 SAP emissions	2005 SAP emissions	2009 SAP emissions	2009 SAP emissions	2012 SAP emissions

Results

Energy consumption

The results are presented first for all dwellings, then for occupied dwellings only. The latter can give a more realistic picture of the stock because vacant properties tend to be in poorer condition and have much more variable heating costs associated with them.

The consumption and emissions results are also presented for space and water heating only, thereby excluding lights and appliance use and cooking. This approach can be useful when analysing the effect of improvements to the building fabric and heating systems which was the focus of HECA.

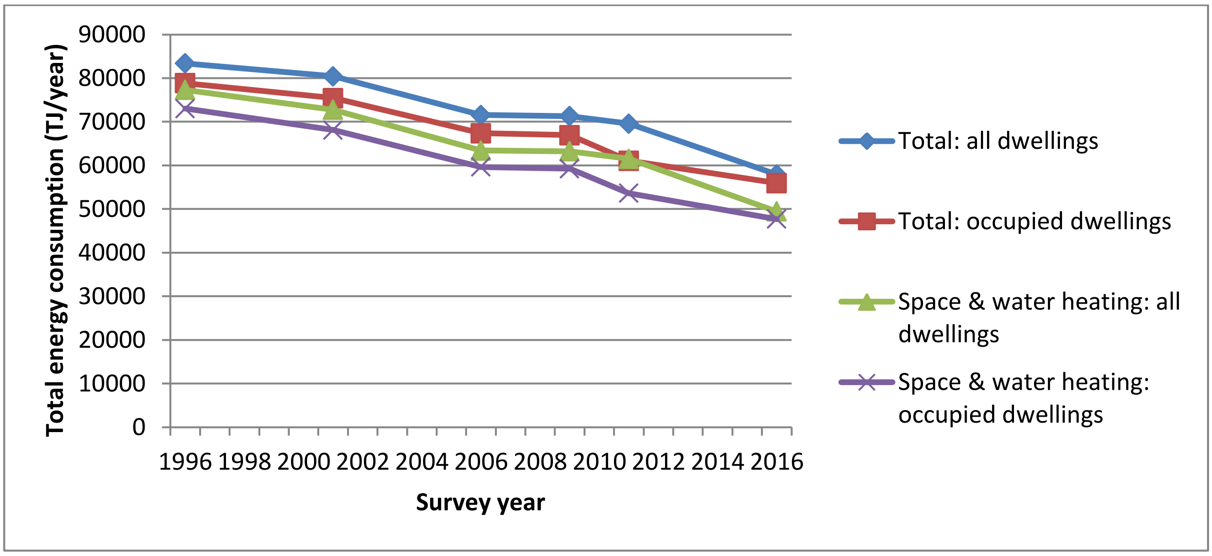
Table 1 shows the energy consumption for the dwelling stock in each of the survey years. This is the sum of the consumption calculated for each individual dwelling using the methodology described above. Figure 2 shows this information graphically. It is clear to see that the general trend since 1996 has been a reduction in energy consumption. This is consistent with improvements to dwellings' fabric energy efficiency (in particular cavity wall insulation) and heating system improvements (condensing central heating systems replacing older, less efficient systems).

The decrease in energy consumption over the latest five year period, 2011 to 2016, for the occupied stock only is similar to the previous five year period (2006 to 2011). There has, however, been a larger reduction in energy consumption for the whole stock (occupied and unoccupied) between 2011 and 2016 compared with the previous five year period. This is partly due to there being fewer vacant dwellings in the 2016 stock (4%) compared with 2011 (7%).

Table 1: Energy consumption in pre-1996 dwellings (Terajoules/year), 1996-2016

	1996	2001	2006	2009	2011	2016
Total energy consumption (all dwellings)	83,384	80,423	71,557	71,315	69,581	57,920
Total energy consumption (occupied dwellings)	78,860	75,445	67,388	66,937	61,091	55,935
Space & water heating consumption (all dwellings)	77,301	72,753	63,427	63,231	61,506	49,461
Space & water heating consumption (occupied dwellings)	73,034	68,127	59,658	59,258	53,641	47,714

Figure 2: Energy consumption in pre-1996 dwellings (Terajoules/year), 1996-2016



Carbon dioxide emissions

Table 2 shows the CO_2 emissions from the pre-1996 dwelling stock. The emissions are constructed by taking the consumption and then applying associated emissions factors (from the SAP specification) for each fuel being used in the dwelling. This will be dominated by the space and water heating fuel in use in each dwelling, typically oil, gas or electricity. Emissions from lights and appliances use are calculated using the carbon dioxide factor for electricity. The results presented here use different emissions factors for different years to reflect the fact that the carbon mix of electricity generation has changed over the years as has the carbon intensity of other fuels, and the understanding of emissions associated with each fuel. Figure 1 shows the emissions factors used for different years.

CO_2 emissions exhibit a similar pattern of reduction to energy consumption apart from in 2009[3] (Figure 3). As with the energy consumption, the CO_2 emissions decreased more for all dwellings compared with occupied dwellings between 2011 and 2016. This is partly due to the smaller proportion of vacant dwellings in 2016 compared with 2011.

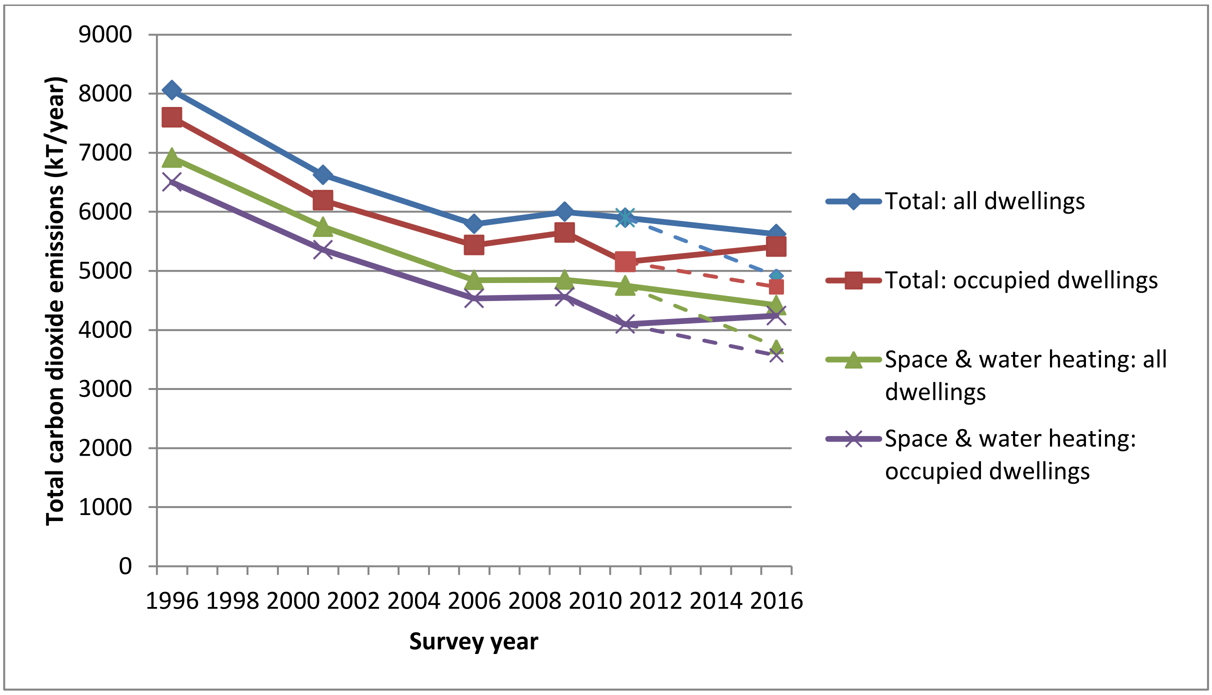
For the 2016 data the model was updated from using the SAP 2009 emissions factors, to using the SAP 2012 factors. These factors include increases in the carbon intensity associated with all the main fuels (including gas, oil and electricity). The use of the SAP 2012 factors for the 2016 data results in an increase in calculated emissions for all uses of these fuels, which is reflected in the rise in emissions that can be seen between the 2011 and 2016 data in the occupied stock. For comparative purposes, the equivalent emissions for 2016, calculated using the SAP 2009 factors, are also shown using a dashed line in Figure 3. This shows a decrease in emissions consistent with what would be expected given the observed reduction in energy use.

[3] In 2009, the modelling switched to using the SAP 2009 carbon emissions factors which incorporated factors for electricity which are significantly higher than in the SAP 2005 specification.

Table 2: Carbon dioxide emissions from pre-1996 dwellings (Kilotonnes/year), 1996-2016

	1996	2001	2006	2009	2011	2016
Total CO_2 emissions (all dwellings)	8,057	6,623	5,791	5,997	5,899	5,621
Total CO_2 emissions (occupied dwellings)	7,597	6,193	5,434	5,649	5,154	5,412
Space & water heating CO_2 emissions (all dwellings)	6,915	5,745	4,845	4,849	4,752	4,419
Space & water heating CO_2 emissions (occupied dwellings)	6,503	5,355	4,534	4,559	4,096	4,244

Figure 3: Carbon dioxide emissions from pre-1996 dwellings (Kilotonnes/year), 1996-2016. All years calculated using SAP 2009 methodology, but with the variable emissions factors shown in Figure 1. Dashed line shows the 2016 data calculated using the SAP 2009 emissions factors for comparative purposes.



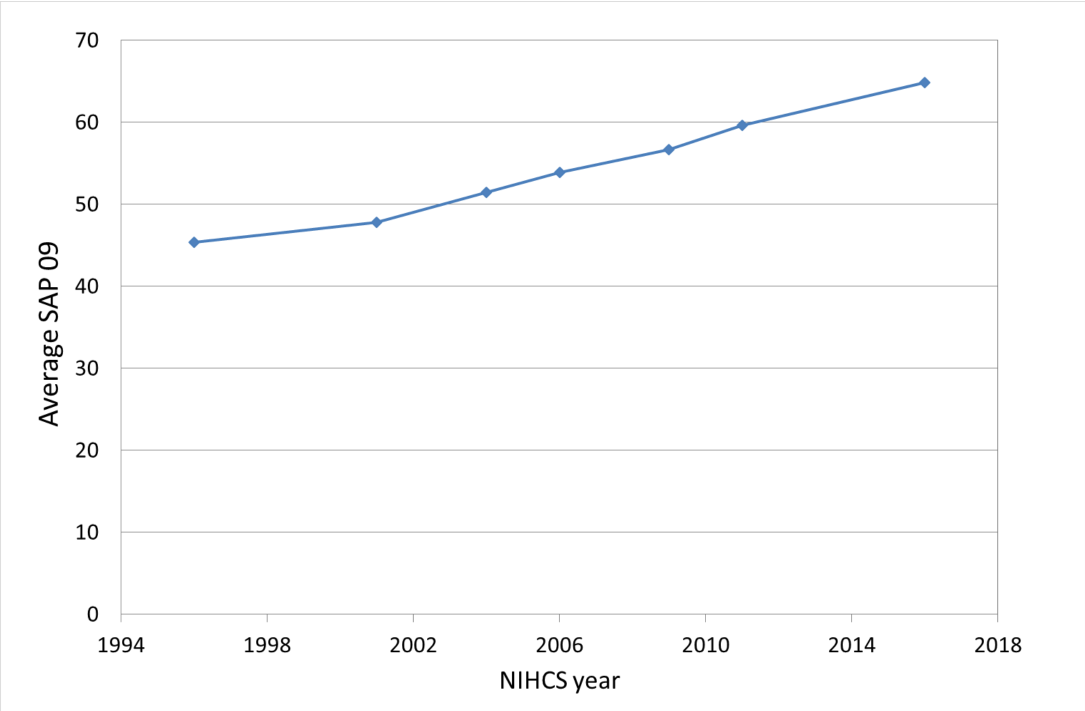
Data quality considerations

All stages of the energy modelling process were heavily validated. This includes at three main points; 1) before data are fed into the energy models 2) during energy modelling and 3) once outputs have been produced from the modelling process. The validation is primarily focussed on maximising data quality but there is also a significant amount of effort undertaken to verify the calculation algorithms that are contained within the SAP methodology. To validate this aspect of the modelling we run a series of cases through SAP reference software and ensure that, as far as NIHCS data allow, the outputs are the same.

Results from the underlying calculations (SAP and BREDEM) are compared with other nations (primarily England) and also with earlier iterations of the NIHCS. We look for consistency across a range of metrics relevant to energy efficiency including the dwelling fabric (wall type, floor type, cavity wall insulation, solid wall insulation, loft insulation presence and thickness), and heating system type, fuel and efficiency. Any patterns are investigated and explained prior to delivery of the final outputs. This process may identify changes that need to be made, either to the input data or the routines in the models. These are all logged and implemented before a final run of the data that feed into the analysis.

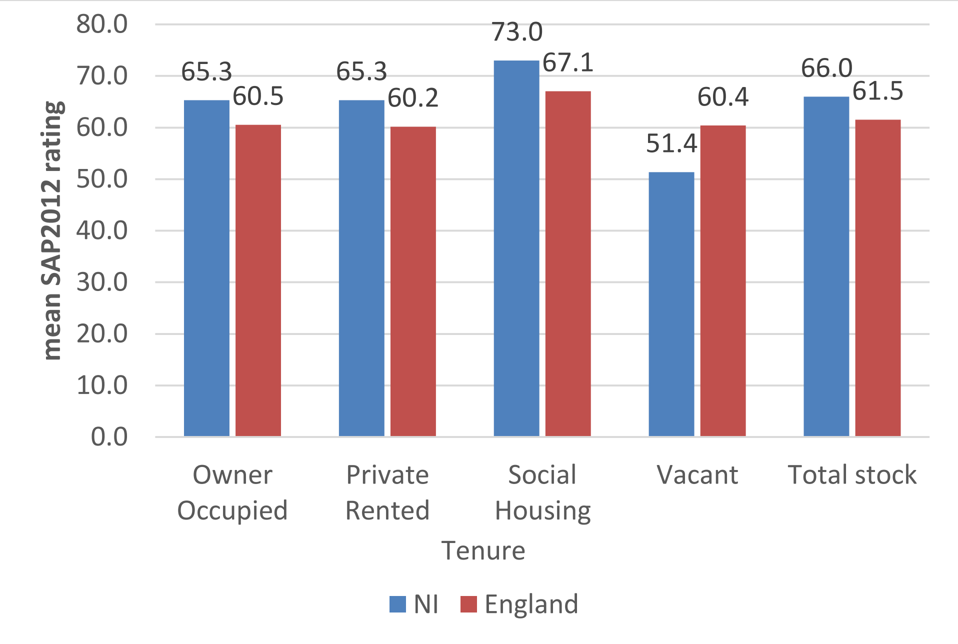
Figure 4 illustrates the change in mean SAP rating for the Northern Ireland stock between 1996 and 2016 using the previous SAP09 methodology. As expected there has been a steady improvement in the energy efficiency of the whole stock over time. Between 2011 and 2016 SAP09 rose from 59.6 to 64.9.

Figure 4: SAP 2009 rating timeline, 1996-2016



The average (mean) Northern Ireland 2016 SAP12 ratings are compared below by tenure to the EHS 2015 published figures for England (Figure 5). With the exception of the vacant stock, the average SAP12 ratings for Northern Ireland are four to six SAP points greater than for England.

Figure 5: SAP 2012 by tenure for Northern Ireland (2016) and England (2015)



Data quality and modelling considerations – strengths and weaknesses

The emissions data required additional checking because the methodology introduces several changes to aspects of the modelling such as emissions factors. The use of different emissions factors makes comparison over time harder because the mix of generation for electricity evolves and the emissions for each kWh will tend to reduce over time as generation plant become cleaner (for example because of the shift from coal and oil to gas and renewables). The justification for using different factors is that the emissions from the housing stock will reflect the emissions of the generation and so as this evolves over time it is reasonable to include this change. It is for this reason that we included an indication in Figure 3 of how the results would look with a consistent emissions factor between 2011 and 2016.

The other modelling approach of note is the decision to use SAP 2009 and BREDEM 2001 for the modelling methodology. The specifications for these are updated periodically to reflect improvements in our knowledge of building physics, to better reflect technology used in buildings such as heating systems (this is particularly relevant as the number and nature of technologies grows and diversifies), and to use more up to date values for items such as fuel prices and weather data. All of this makes comparison over time harder and so it has been decided to maintain greater consistency and allow for more direct comparability.

Data quality is in general very high. The surveyors are all highly experienced, are thoroughly trained and used tablet PCs with inbuilt validation to capture errors at source. BRE also undertook extensive acceptance testing of the data prior to their use in modelling. As described, the modelling process also included extensive quality assurance and validation. It can be seen from the results that there is always variability in sample survey data and this is particularly true of vacant dwellings. Vacant properties can often have quite extreme problems with repair and condition which, although they are few in number, can have a disproportionate effect on results. This is one reason that vacant dwellings have been removed for some of the analysis presented here.

Appendix A Tables

Note: The confidence intervals below are based on the assumption that the sample is a simple random sample. The confidence intervals do not account for all potential sources of error, e.g. the NIHCS sample design, measurement error and surveyor variability.

The figures in the main report are expressed as totals for the whole stock. In order to gain some idea of the uncertainty around these figures this appendix provides the 95% confidence intervals for the mean consumption and carbon dioxide emissions. It shows that, for the 2009 and 2011 surveys in particular, the sample sizes are such that it is not possible to say that the change observed is not due to chance. However, the confidence interval findings for mean energy consumption and carbon dioxide emissions, for both all dwellings and occupied dwellings, suggest that the decreases from 2011 to 2016 are not due to chance.

Tables 3 to 6 are the confidence intervals for the figures for all pre-1996 dwellings and tables 7 to 10 are those for occupied dwellings only.

Table 3: Mean energy consumption (all dwellings) (kWh/year)

	Mean	Unweighted base	Standard Error	95% confidence interval	
				lower	upper
1996	38,443	10,194	284.4	37,886	39,001
2001	37,019	5,827	303.9	36,424	37,615
2006	32,216	4,969	287.8	31,652	32,780
2009	32,373	1,889	508.3	31,377	33,369
2011	32,084	1,121	587.8	30,931	33,236
2016	26,647	1,607	356.7	25,948	27,347

Base: All pre-1996 dwellings

Table 4: Mean energy consumption for space & water heating (all dwellings) (kWh/year)

	Mean	Unweighted base	Standard Error	95% confidence interval	
				lower	upper
1996	35,639	10,194	279.3	35,091	36,186
2001	33,489	5,827	294.7	32,911	34,067
2006	28,556	4,969	277.3	28,012	29,099
2009	28,703	1,889	493.7	27,736	29,671
2011	28,360	1,121	566.8	27,249	29,471
2016	22,756	1,607	337.7	22,094	23,418

Base: All pre-1996 dwellings

Table 5: Mean carbon dioxide emissions (all dwellings) (kg/year)

	Mean	Unweighted base	Standard Error	95% confidence interval	
				lower	upper
1996	13,372	10,194	82.7	13,210	13,535
2001	10,975	5,827	89.1	10,801	11,150
2006	9,386	4,969	83.7	9,222	9,550
2009	9,801	1,889	153.9	9,499	10,102
2011	9,791	1,121	175.5	9,447	10,135
2016	9,309	1,607	130.4	9,054	9,565

Base: All pre-1996 dwellings

Table 6: Mean carbon dioxide emissions from space & water heating (all dwellings) (kg/year)

	Mean	Unweighted base	Standard Error	95% confidence interval	
				lower	upper
1996	11,477	10,194	79.4	11,321	11,632
2001	9,520	5,827	85.6	9,352	9,688
2006	7,853	4,969	79.5	7,697	8,009
2009	7,924	1,889	146.6	7,637	8,211
2011	7,888	1,121	164.8	7,565	8,211
2016	7,320	1,607	120.3	7,084	7,555

Base: All pre-1996 dwellings

Table 7: Mean energy consumption (occupied dwellings) (kWh/year)

	Mean	Unweighted base	Standard Error	95% confidence interval	
				lower	upper
1996	38,182	9,535	294.0	37,606	38,758
2001	36,561	5,340	294.2	35,984	37,137
2006	32,106	4,501	287.7	31,542	32,669
2009	32,202	1,692	460.0	31,301	33,104
2011	30,553	1,026	531.9	29,510	31,595
2016	26,524	1,555	357.8	25,822	27,225

Base: Occupied pre-1996 dwellings

Table 8: Mean energy consumption for space & water heating (occupied dwellings) (kWh/year)

	Mean	Unweighted base	Standard Error	95% confidence interval	
				lower	upper
1996	35,362	9,535	288.7	34,796	35,928
2001	33,015	5,340	283.8	32,458	33,571
2006	28,423	4,501	276.2	27,881	28,964
2009	28,508	1,692	442.7	27,641	29,376
2011	26,827	1,026	507.3	25,832	27,821
2016	22,625	1,555	338.2	21,963	23,288

Base: Occupied pre-1996 dwellings

Table 9: Mean carbon dioxide emissions (occupied dwellings) (kg/year)

	Mean	Unweighted base	Standard Error	95% confidence interval	
				lower	upper
1996	13,241	9,535	85.0	13,075	13,408
2001	10,804	5,340	85.4	10,637	10,972
2006	9,319	4,501	82.5	9,158	9,481
2009	9,784	1,692	137.8	9,514	10,054
2011	9,279	1,026	156.4	8,972	9,585
2016	9,238	1,555	129.1	8,985	9,491

Base: Occupied pre-1996 dwellings

Table 10: Mean carbon dioxide emissions from space & water heating (occupied dwellings) (kg/year)

	Mean	Unweighted base	Standard Error	95% confidence interval	
				lower	upper
1996	11,335	9,535	81.5	11,175	11,495
2001	9,343	5,340	81.4	9,183	9,502
2006	7,777	4,501	77.8	7,624	7,929
2009	7,895	1,692	129.0	7,642	8,148
2011	7,375	1,026	143.6	7,094	7,657
2016	7,245	1,555	118.6	7,013	7,478

Base: Occupied pre-1996 dwellings

Report Ends