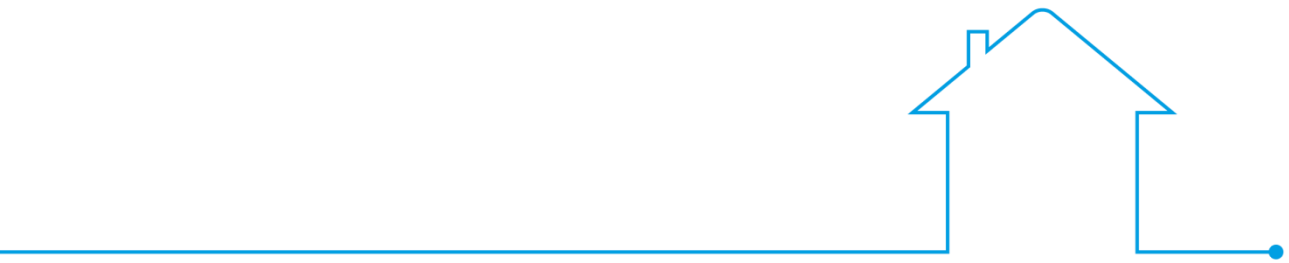
Department of Energy & Climate Change

NATIONAL ENERGY EFFICIENCY DATA-FRAMEWORK

Summary of analysis using the National Energy Efficiency Data-Framework (NEED)



June 2016

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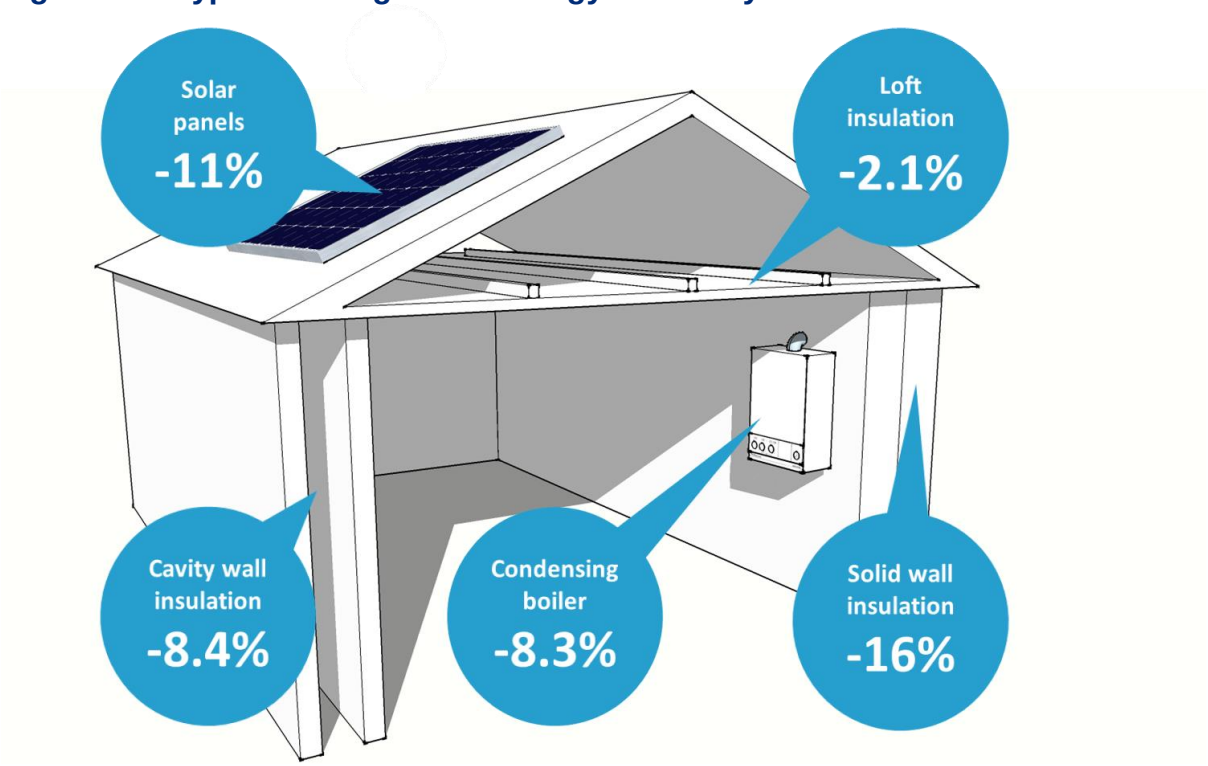


The National Energy Efficiency Data-Framework (NEED) was set up by DECC to provide a better understanding of energy use and energy efficiency in domestic and non-domestic buildings in Great Britain. This publication presents:

- analysis of domestic gas and electricity consumption in 2014 by property attribute, household characteristics, geography and socio-demographic classification;
- analysis of the impact of installing energy efficiency measures in 2013 on a household's gas consumption; and
- three annexes covering analytical developments based on NEED.

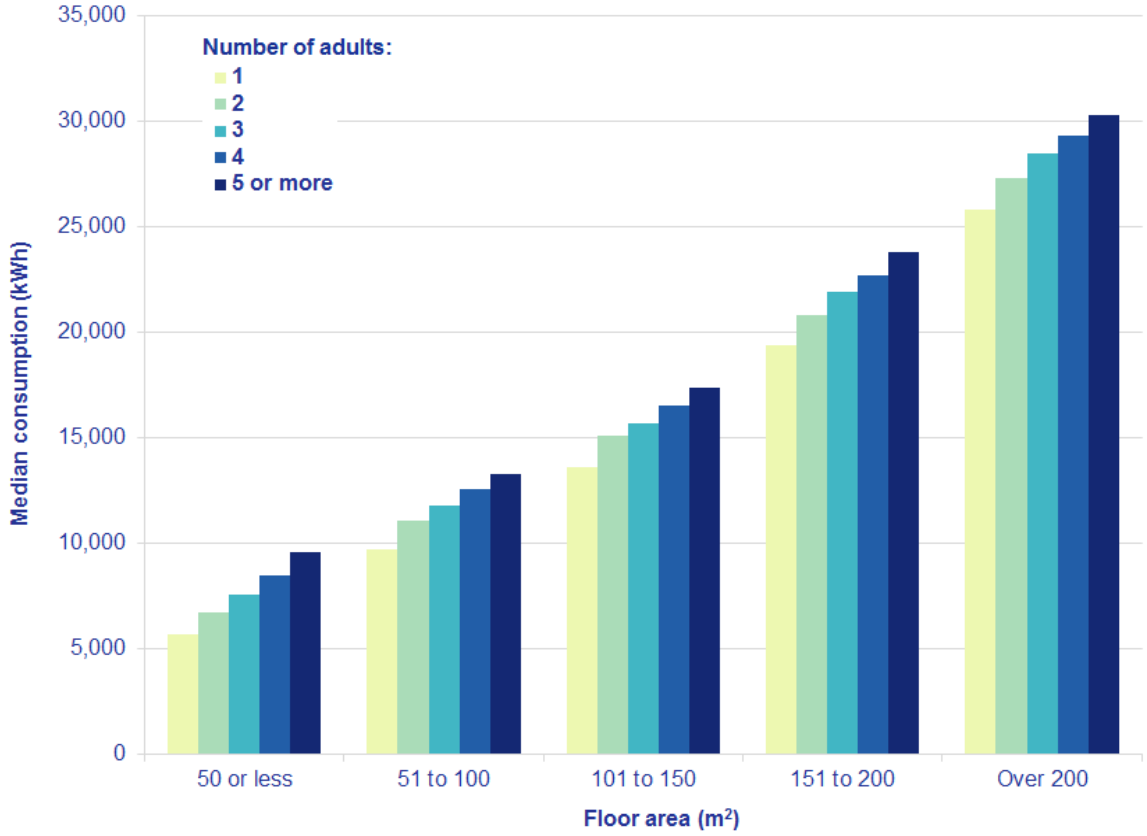
All results produced for this report are for annual consumption based on a representative sample of data for England and Wales unless stated. Results are produced using the

methodology outlined in the domestic NEED methodology note published alongside this report[1].

Domestic consumption

Chapter 3 presents evidence of how energy is used in households. For example, Figure 1.2 below shows the trend in median gas consumption by property size and the number of adult occupants. The relationship between floor area and gas consumption is roughly linear, with consumption per square meter remaining generally consistent across all of the size categories. The absolute increase in gas consumption associated with an increase in occupiers is also broadly constant across the area size categories; the difference in consumption between 1 occupier and 4 occupiers is 3,000-3,500 kWh regardless of how large the property is. Accordingly, for the same increase (from 1 to 4 occupiers) the *percentage* increase declines from 51 per cent in the 50 m^2 or less category, to 13 per cent in the over 200 m^2 category.

Figure 1.2: Median gas consumption (kWh) by floor area and number of adults, 2014



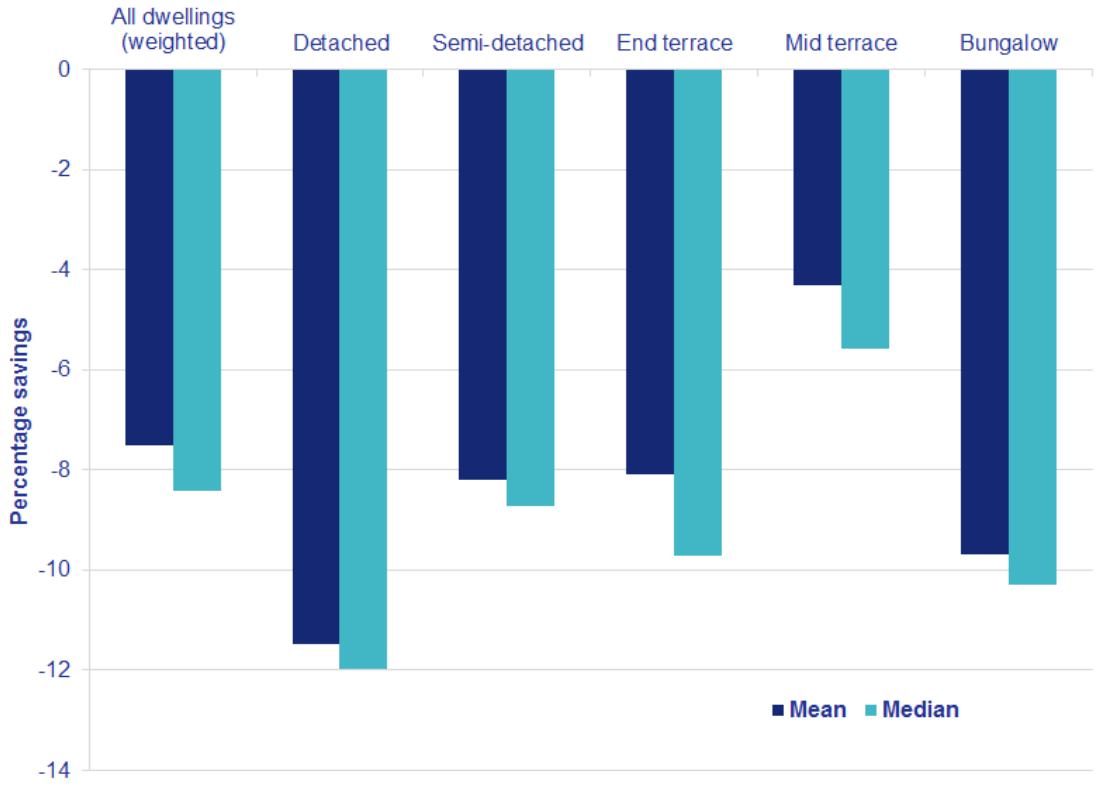
[1] https://www.gov.uk/government/publications/domestic-national-energy-efficiency-data-framework-need-methodology

Although some of the variation in gas and electricity consumption can be explained by variables contained within NEED, there are other factors to consider, for example differences in building construction, differences in performance of heating systems and appliances, and importantly differences in the behaviours of the individuals within each household.

Impact of measures

Estimates of the impact of installing an energy efficiency measure on a household's gas consumption continue to show that considerable savings can be made by properties installing a single energy efficiency measure, or a combination (for example cavity wall insulation and loft insulation). Single measure savings are presented in Figure 1.1. Figure 1.3 below shows the observed percentage savings in gas consumption for three bedroom properties installing cavity wall insulation in 2013 by property type. When looking at three bedroom properties, detached properties experienced the greatest typical saving, with mid terrace properties seeing the smallest reduction in gas consumption. This variation is largely due to the different number of external walls associated with each property type; mid terrace properties see the smallest savings since they only have two external walls, whereas detached, semi-detached and end terrace all have at least three.

Figure 1.3: Observed savings (weighted) in gas consumption for three bedroomed properties having cavity wall insulation installed in 2013, by property type



Footnotes:
1. Consumption data from sub-national gas and electricity consumption statistics 2014, https://www.gov.uk/government/organisations/department-of-energy-climate-change/about/statistics
2. Household characteristics data sourced from the Valuations Office Agency as at April 2016

Analytical developments

In addition to the analysis highlighted above, a number of developmental annexes accompany this report. Annex C details a novel principal component analysis into factors that can predict domestic gas consumption, combining NEED with data from the English Housing Survey (EHS) and from DECC's Fuel Poverty analysis. The resulting model shows that building and demographic characteristics accounted for 44 per cent of the variance in gas consumption. The model was then extended, in a hierarchical fashion, by adding previous consumption as a proxy measure for previous behaviour. This caused a large increase in model fit (to 81 per cent), indicating that the behaviour of householders explains a significant proportion of the overall variation in the demand for gas. Floor area was found to be the most important building characteristic for determining demand, and the presence of children the most important demographic characteristic. The latter may reflect a preference of those with young families to heat their home to a higher temperature, and also a tendency for the home to be occupied (and heated) a greater proportion of the time. The age of the oldest resident was also found to be significant, with over the 60s being associated with higher demand. Again this is likely due to retired individuals spending more time in the home.

Annex D explores existing research into the price elasticity of gas, i.e. the impact that price changes have had on domestic consumption. Although previous estimates of the price elasticity vary, it would appear that prices, which have doubled over the last decade, are likely to have had a significant impact on demand levels (with a conservative estimate indicating that price increases have accounted for around a third of the decline in domestic gas consumption over the period). The annex also explores the extent to which gas price elasticity varies by household income group. Preliminary evidence suggests that lower income groups are notably more sensitive to changes in price. The estimated elasticities imply that the response to a price change would be 25 per cent greater in the lowest income group compared to the highest income group.

Annex E examines the impact of the weather correction process that is applied to the gas consumption data within NEED, which allows comparisons to be made over time without the influence of temperature fluctuations. This reveals that in certain regions of the UK in 2014, temperature variation accounted for up to five per cent of the variation in gas consumption.

2. Introduction

The National Energy Efficiency Data-Framework (NEED) project was set up by DECC to assist in its plan to promote energy efficiency and support vulnerable consumers.

It is a key element of the evidence base supporting DECC to:

- Develop, monitor and evaluate key policies (including the Green Deal and ECO);
- Identify energy efficiency potential which sits outside the current policy framework;
- Develop a greater understanding of the drivers of energy consumption; and
- Gain a deeper understanding of the impacts of energy efficiency measures for households and businesses

The data framework provides the largest source of data available for analysis of consumption and the impacts of installing energy efficiency measures. This report provides updated domestic/household energy consumption results to include 2014 gas and electricity consumption data. It also includes updated estimates of the impact of installing energy efficiency measures on a household's gas consumption for measures installed in 2013.

Headline results and key findings are presented in this report, with detailed data tables including breakdowns by property attributes and household characteristics published alongside this report (see Annex F for details of all published tables). In addition to the domestic consumption and impact of measures headline results there are a number of other outputs being published:

- Annex A: Quality Assurance: outlines how data contained within domestic NEED compares with other sources of data
- Annex B: Scotland - a summary of domestic consumption in Scotland during 2014
- Annex C: Predicting gas consumption - factors that can predict gas consumption using principal component analysis
- Annex D: Gas price elasticities - the impact of gas prices on domestic consumption, a discussion of available evidence
- Annex E: Analysis of weather correction on gas consumption statistics on 2014
- Annex F: Data tables: contains details of all published tables

- Annex G: Summary of Building Regulations - relating to loft insulation, wall insulation, boiler standards and heating controls
- Multiple attributes: a table presenting gas and electricity consumption for 2014 by multiple property attributes
- Table creator: a tool which allows users to create bespoke cross tabulations using gas and electricity consumption data (2005 to 2014) by property attributes and household characteristics

A domestic NEED methodology note has been published alongside this publication which includes details of how estimates of domestic electricity and gas consumption by property attributes and household characteristics are produced. It also sets out the methodology for estimating the saving in gas consumption following the installation of retro-fit energy efficiency measures (e.g. cavity wall insulation, loft insulation) and provides background on the users and uses of the data and details of the revisions policy. This note can be accessed from the following link:

https://www.gov.uk/government/publications/domestic-national-energy-efficiency-data-framework-need-methodology

The statistics presented within NEED were previously assessed by the UK Statistics Authority against the Code of Practice for Official Statistics. The UK Statistics Authority published its report on 12 June 2014: http://www.statisticsauthority.gov.uk/assessment/assessment/assessment-reports/index.html.

The UK Statistics Authority designated these statistics as National Statistics in February 2015, in accordance with the Statistics and Registration Service Act 2007 and signifying compliance with the Code of Practice for Official Statistics following the implementation of a small number of requirements across the range of DECC statistics assessed. These actions were taken forward before the end of September 2014.

Designation can be broadly interpreted to mean that the statistics:

- Meet identified user needs.
- Are well explained and readily accessible.
- Are produced according to sound methods.
- Are managed impartially and objectively in the public interest.

Once statistics have been designated as National Statistics it is a statutory requirement that the Code of Practice shall continue to be observed.

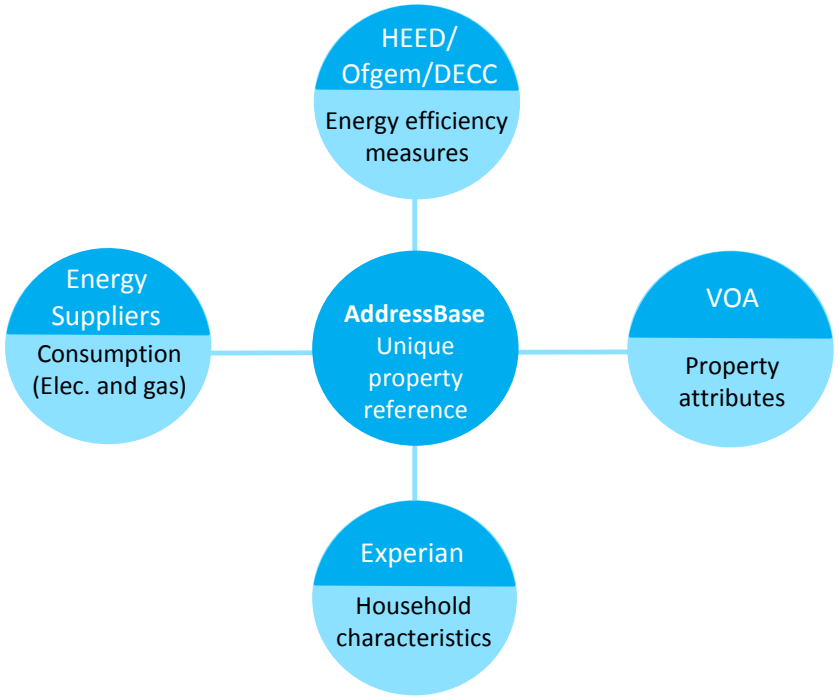
The remainder of this section gives a brief overview of NEED. For any queries or feedback on this publication please email:

EnergyEfficiency.Stats@decc.gsi.gov.uk

2.1 NEED overview

NEED is a framework for combining data from existing sources (administrative and commercial) to provide insights into how energy is used and what the impact of energy efficiency measures are on gas and electricity consumption, for different types of properties and households. The address information in each dataset is used to assign a unique property reference number (UPRN) to each record. Data from different sources can then be matched to each other via the UPRN (Figure 2.1). The principle is the same for both the domestic and non-domestic sector, though different data sources are used.

Figure 2.1: Structure of domestic NEED



Six key data sources have been used to analyse domestic energy consumption and the impact of installing energy efficiency measures: meter point electricity and gas consumption data, Valuation Office Agency (VOA) property attribute data, the Homes Energy Efficiency Database (HEED), Central Feed-in Tariff Register[2] and Renewable Heat

[2] Further information on the Central Feed-in Tariff register can be found via this webpage: https://www.gov.uk/government/statistical-data-sets/monthly-central-feed-in-tariff-register-statistics

Incentive (RHI)[3], Green Deal and ECO data held by DECC[4], all of which contain information on energy efficiency measures installed, and data modelled by Experian on household characteristics. In addition to these six main data sources feeding into the framework at a property level there are a number of other indicators that have been assigned to the property based on its geographic location. For example, an index of multiple deprivation and a fuel poverty indicator are assigned based on the Lower Layer Super Output Area (LSOA).

NEED has supported a number of DECC policies. It has been used to understand the reduction in consumption for households installing energy efficiency measures. To date NEED has looked at savings from a number of measures, including cavity wall insulation, loft insulation, installation of condensing boilers and solid wall insulation. The estimates from NEED were used to inform "in use factors" for the Green Deal. Data on consumption has informed Fuel Poverty analysis so there is a better understanding of actual consumption for different types of properties and households and therefore a better understanding of how policy options will impact on different households.

DECC would like to thank all those who made this analysis possible, including: Energy Suppliers, Gas Safe, the Energy Savings Trust and the Valuation Office Agency.

All analysis of domestic properties presented in this report is based on a representative sample of properties in England and Wales, stratified by local authority, number of bedrooms, property type and property age.

The rest of this report covers:

- Domestic Energy Consumption: analysis of domestic gas and electricity consumption by property attributes, household characteristics, geography and socio-demographic classifications.
- Impact of Energy Efficiency Measures in Homes: analysis of the impact of installing energy efficiency measures on a household's gas consumption.

[3] Further information on the Renewable Heat Incentive can be found via this webpage: https://www.gov.uk/government/collections/renewable-heat-incentive-statistics

[4] DECC collect the Green Deal and ECO data from a number of different sources. Further information on this can be found in the Domestic Green Deal and ECO Statistics Methodology Note: https://www.gov.uk/government/statistics/domestic-green-deal-and-eco-statistics-methodology-note

3. Domestic energy consumption

This section presents analysis of domestic gas and electricity consumption by property attributes, household characteristics, geography and socio-demographic classifications.

Results are based on a representative sample of approximately four million properties for England and Wales, with the exception of trends in consumption which covers only England between 2005 and 2010 and both England and Wales for 2011 to 2014[5]. A sample is used rather than the complete dataset in order to increase processing speed, reduce cost and to ensure that DECC is not processing more data than necessary.

All consumption figures presented in this section are based on valid domestic gas and electricity consumption[6] and are rounded to the nearest 100 kWh. All gas consumption data are presented on a weather corrected basis[7], this means that the consumption for each household has been adjusted to account for differences in temperature and wind in each year. This allows for a more consistent comparison of gas consumption over time[8]. Electricity consumption data are not weather corrected. This is because gas is predominantly a heating fuel and hence its use depends heavily on the weather whereas electricity is used for a much wider variety of reasons (and far less often as a heating fuel) so consumption is less affected by the weather.

The relationship between energy use and any individual characteristic is complex, but there is a high correlation between certain characteristics and a household's energy use (for example, size of property or household income). This section provides insight into how each characteristic relates to energy use, but makes no attempt to control for other characteristics[9]. The results presented here are consistent with results for earlier years presented in previous reports.

[5] Results for 2005 to 2014 presented in this report can be considered as a continuous trend. Refer to the methodology note for further detail: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/437164/Domestic_NEED_Methodology_June_2015.pdf

[6] Valid domestic gas consumption readings are taken to be values between 100 kWh and 50,000 kWh (inclusive). Domestic electricity consumption is considered valid if it is between 100 kWh and 25,000 kWh (inclusive). Gas and electricity consumption values which are suspected to be estimated readings are excluded.

[7] More information about the weather correction methodology can be found here: https://www.gov.uk/government/statistics/overview-of-weather-correction-of-gas-industry-consumption-data

[8] Users should note that the weather correction factor applied to the consumption data is modelled and as such may not entirely remove the effects of extreme weather in a single year.

[9] See Annex C where principal component analysis is used to investigate the main drivers of gas demand, with determining factors considered simultaneously.

3.1 Headline domestic consumption

In 2014, the median[10] gas consumption for all properties in the sample was 12,000 kWh, with median electricity consumption at 3,300 kWh. However, within the distribution there is a range of consumption as can be seen from the lower and upper quartiles[11] shown in Table 3.1. The table also shows that mean consumption is larger than median consumption, by 9 per cent for gas and 24 per cent for electricity. In the rest of this section, median consumption has been used to represent typical consumption. It is a more appropriate measure of typical consumption than the mean because the mean can be influenced by a relatively small number of high consuming households that are not typical of the rest of the population.

Table 3.1 also shows that there is more variation in electricity consumption than gas consumption. The standard deviation[12] is 57 per cent of the mean for gas and 81 per cent for electricity. The larger variability (or spread of data) for electricity is likely to be due to the wider range of uses of electricity, including the variation between households that use electricity as the main heating fuel and those that do not, as well as the use of electricity for secondary heating.

The distribution of gas and electricity consumption in 2014 is shown in more detail in Figure 3.1. It shows that generally most households consume around 12,000 kWh of gas, and fewer households consuming higher volumes of gas, which is indicated by the positive skew of the distribution. The same can be said about the distribution of electricity with the positive skew being more pronounced.

Table 3.1: Annual consumption summary statistics, 2014

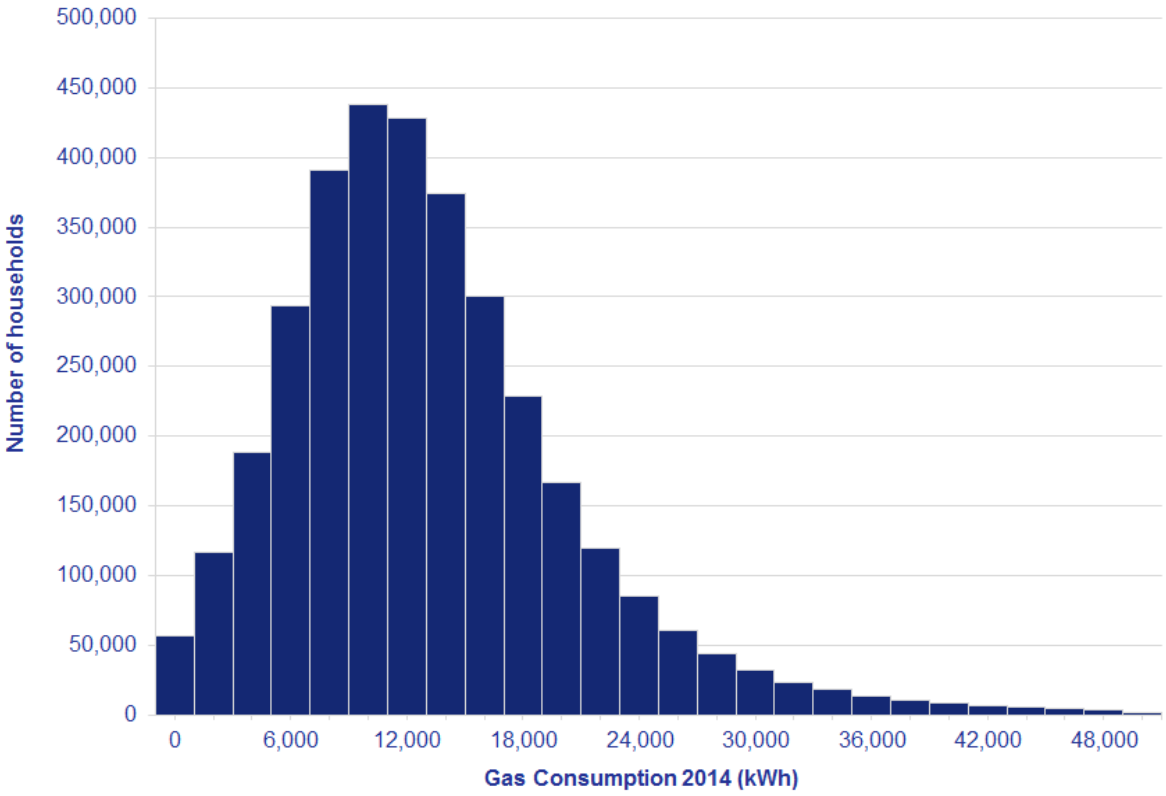
(kWh)

	Mean	Standard deviation	Lower quartile	Median	Upper Quartile
Gas	13,100	7,400	8,100	12,000	16,800
Electricity	4,100	3,300	2,100	3,300	5,000

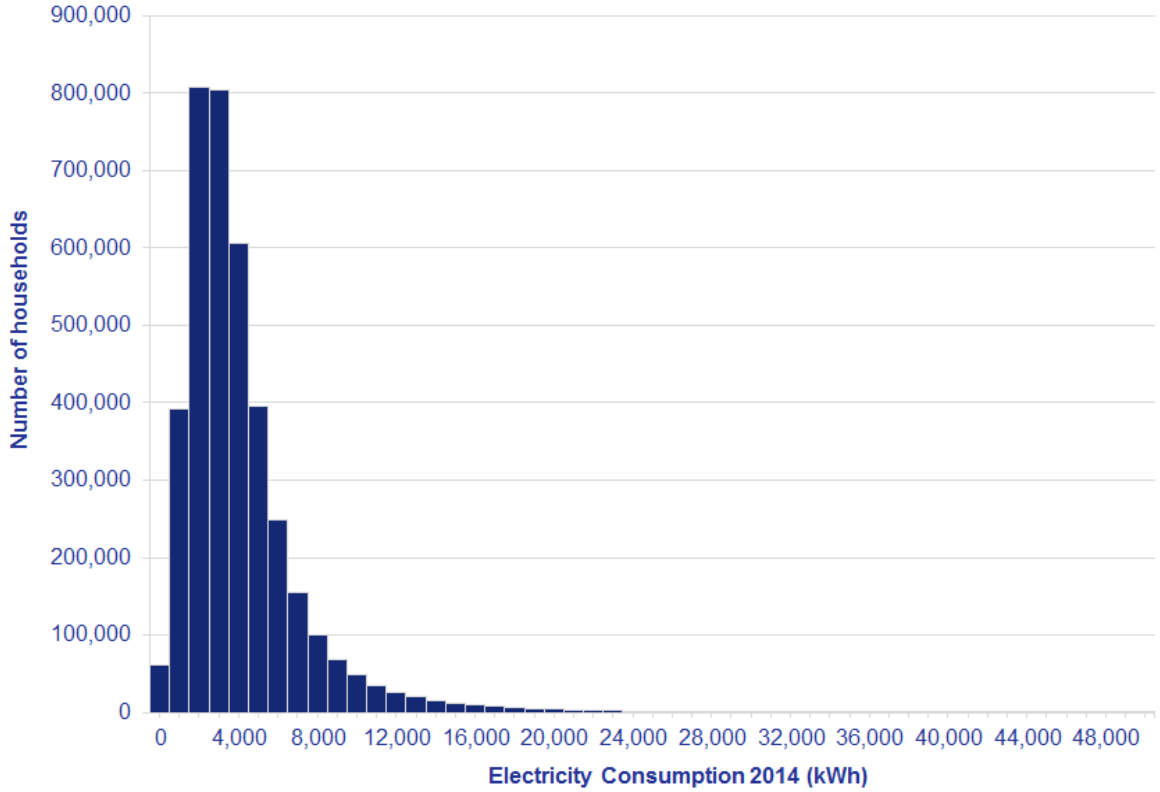
[10] The median is the middle value of the distribution, i.e. the consumption value where half of the households have lower consumption and half have a higher one.
[11] Quartiles (including the median) divide the consumption values into four parts containing the same number of households. The lower quartile is the consumption value where 25 per cent of households have lower consumption and 75 per cent have higher. The upper quartile is the consumption value where 25 per cent of households have higher consumption and 75 per cent have lower.
[12] The standard deviation is a number which measures the spread of a group of values from the average (mean), or expected value.

Figure 3.1: Distribution of consumption, 2014

(a) Gas consumption (kWh)



(b) Electricity consumption (kWh)



3.2 Domestic consumption breakdowns

This section presents domestic gas and electricity consumption by property attributes, household characteristics, geography and socio-demographic classifications. Annex F shows details of all consumption tables available from NEED. For all variables, the numbers of households in the sample along with mean and median figures for consumption are included in the headline tables published alongside this report. Additional statistics to describe the pattern of consumption such as standard deviation and quartiles are included in the additional tables published alongside this report.

In line with previous years, domestic electricity and gas consumption have been published by fuel poverty quintile, index of multiple deprivation quintile and rural urban classification. These data are available for annual electricity and gas consumption between 2011 and 2014.

Figure 3.2 shows typical electricity and gas consumption for households in 2014, by property type. It can be observed that flats consume the least amount of electricity and gas, in particular purpose-built flats, which consumed 20 per cent less gas in 2014 than converted flats, with typical consumptions of 6,500 kWh and 8,100 kWh respectively. This could be a result of the high proportion of purpose-built flats constructed for social housing, which is known to be more energy efficient[13] and therefore consumes smaller quantities of gas.

[13] The energy efficiency of the housing stock has improved between 2005 and 2013 for all households. Figure 2.9 on page 51 of the English Housing Survey headline report 2013-14 shows that in particular properties owned by a housing association have a higher Standard Assessment Procedure (SAP) rating. The report can be found on the following link: https://www.gov.uk/government/statistics/english-housing-survey-2013-to-2014-headline-report.

Figure 3.2: Median consumption (kWh) by property type, 2014

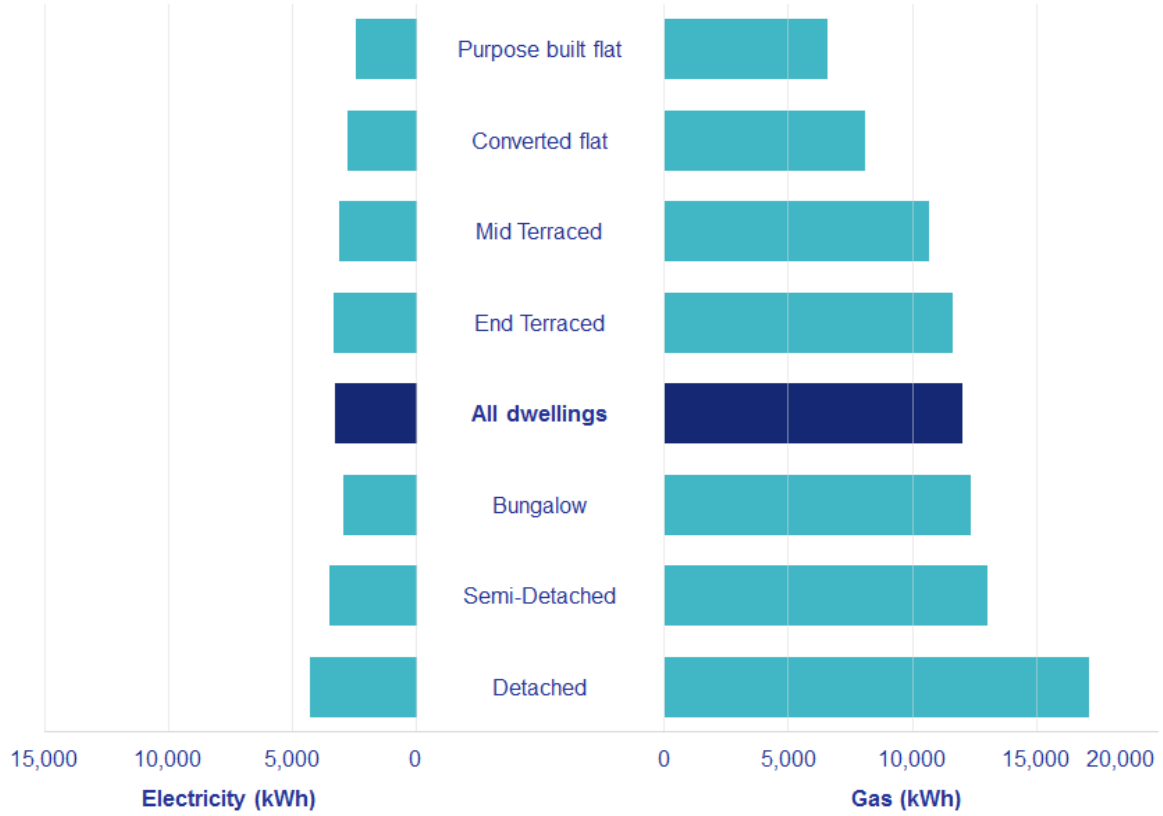


Figure 3.2 also shows that detached houses typically consume more electricity and gas than any other property type. In 2014, a detached house typically consumed 4,300 kWh of electricity and 17,100 kWh of gas, which equates to a consumption percentage difference of 161 per cent more gas and 74 per cent more electricity than a purpose-built flat in 2014. The large difference in gas consumption can be partly explained by the use of gas as a heating fuel and the isolation of a property. As a detached house is not attached to another property, a higher proportion of heat is likely to be radiated from the walls, whereas a flat is surrounded by other flats that also generate heat, which means it is a more efficient property type for keeping the occupants warm. It is also important to note that detached houses are typically the largest property type and therefore will require more gas to heat than a smaller property.

Bungalows typically consume more gas than their typical electricity consumption suggests. Figure 3.2 shows that although a bungalow generally consumed less electricity than a mid-terraced property in 2014, its typical consumption of gas exceeded that of a mid-terraced property and an end-terraced property. This is due to a higher number of exposed walls, therefore less insulation and higher gas consumption to heat the property.

Figure 3.3 shows typical gas consumption by property size and the number of adult occupiers[14]. As can be seen from the chart, floor area is an important determinant of gas demand, with the largest floor area category (over 200 m^2), consuming over four times as much gas as the smallest category (50 m^2 or less). The relationship between floor area and gas consumption is roughly linear, with consumption per square meter remaining broadly consistent across all of the area categories.

Figure 3.3 also shows the effect of the number of household occupants on gas consumption, within each property size band. As the chart shows, the amount of gas used increases for every additional adult that lives in the property. This could reflect the fact that as the number of occupants increases, the proportion of time that a home is occupied by at least one person increases, and so the proportion of time that the property is heated is likely to increase. It is also likely that as the number of occupants increases, the proportion of a property that is heated increases. It is interesting to note that the absolute increase in gas consumption associated with an increase in occupiers is generally consistent across the area size categories; the difference in consumption between 1 occupier and 4 occupiers is 3,000-3,500 kWh regardless of how large the property is. Accordingly, for the same increase (from 1 to 4 occupiers) the *percentage* increase declines from 51 per cent in the 50 or less m^2 category, to 13 per cent in the over 200 m^2 category.

[14] Available data shows only the number of adult occupiers within each property; children are excluded.

Figure 3.3: Median gas consumption (kWh) by floor area and number of adults, 2014

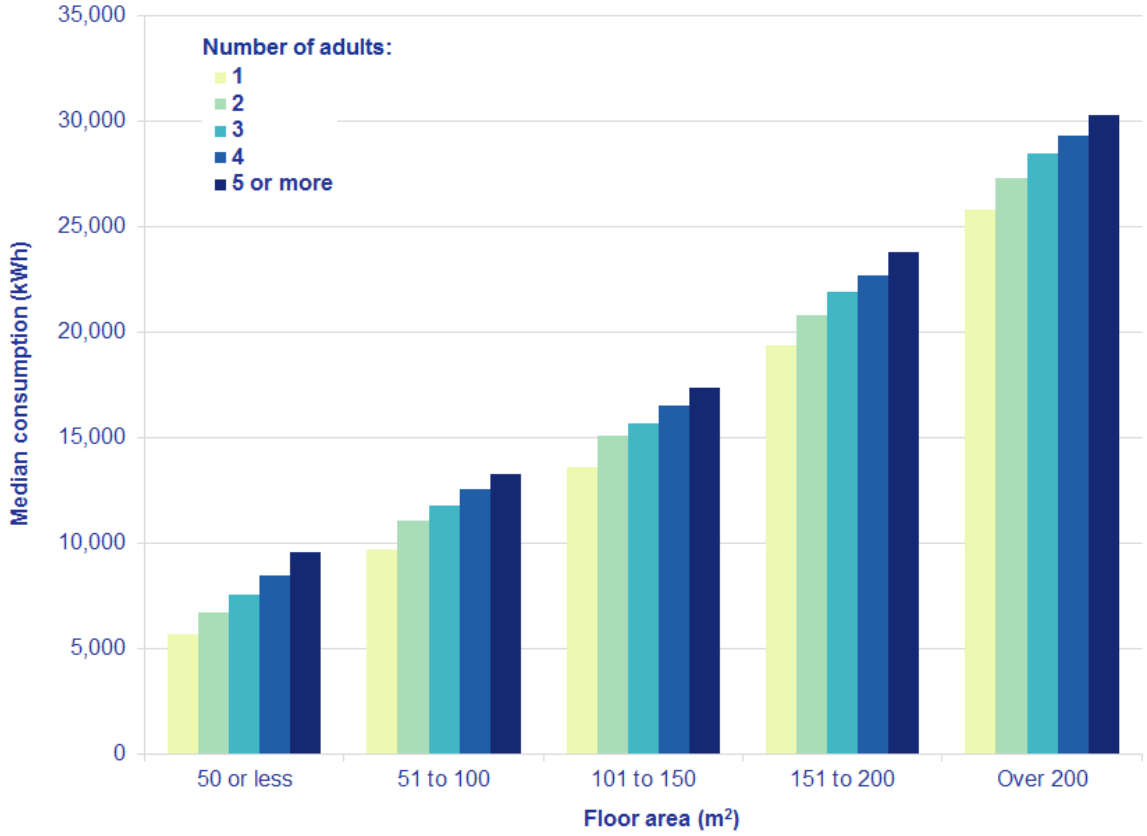


Figure 3.3 was created using data from the NEED table creator tool using rounded data. This tool is designed to provide users with the ability to create bespoke cross tabulations on electricity and gas consumption by property attributes and household characteristics. Two variables can be selected (e.g. Index of Multiple Deprivation quintile and number of bedrooms) and the table will show the number of observations, mean and median consumption. There is also a choice of fuel (electricity or gas). Where available, data for each year from 2005 to 2014 are included. The data used in the creation of the tables can also be downloaded as a comma separated values (.csv) file for ease of reuse. The tool and data files can be found at the following location: https://www.gov.uk/government/statistical-data-sets/need-table-creator.

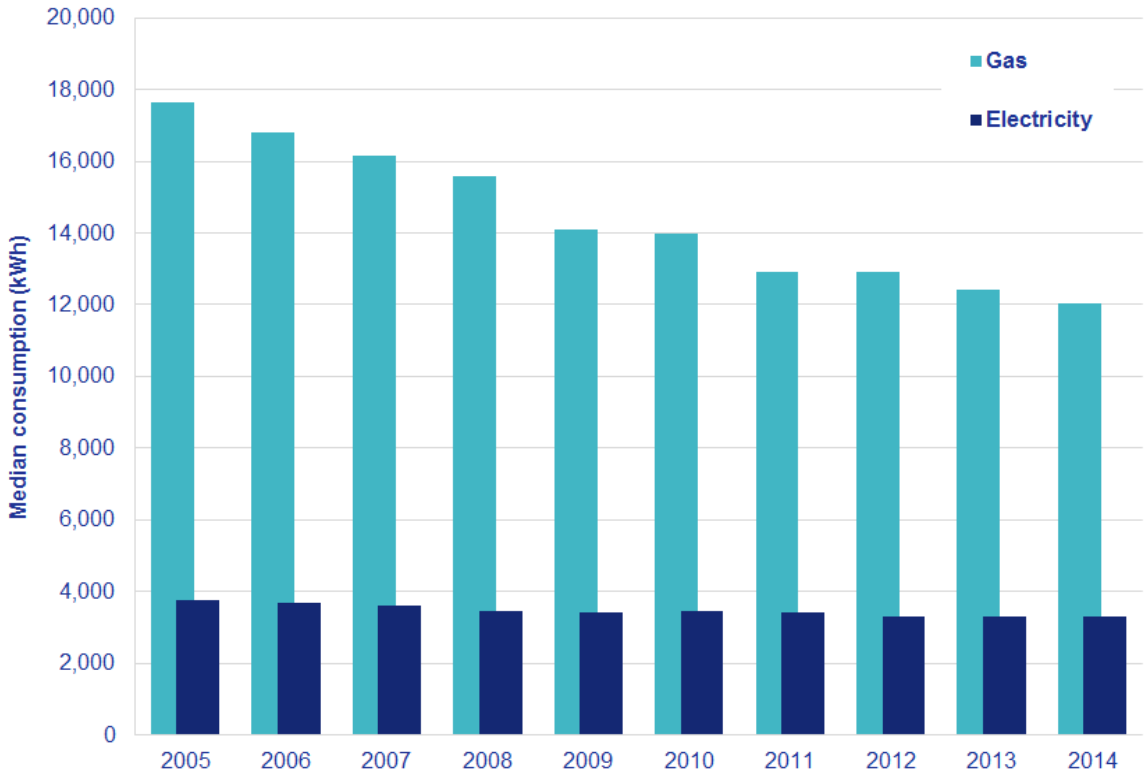
3.3 Trends in domestic consumption

This section provides analysis of the trends in median gas and electricity consumption between 2005 and 2014 for different property attributes and household characteristics. Figure 3.5 shows the median gas and electricity consumption for all households in the NEED sample with valid consumption in each year from 2005 to 2014. Data for 2005 to 2010 cover England only and later data (2011 onwards) cover both England and Wales.

Figure 3.4 shows that median consumption for both gas and electricity has been steadily declining over the period. Median gas consumption has fallen by 32 per cent between 2005 and 2014. Between 2013 and 2014, median gas consumption decreased by 3 per cent. The largest drop was between 2008 and 2009, with a decrease in median annual consumption of 9 per cent. Median electricity consumption decreased by 12 per cent between 2005 and 2014. Between 2013 and 2014 median electricity consumption remained constant.

This reduction in consumption over time could be a result of a number of factors. These potentially include: energy efficiency improvements in households[15] such as: new boilers, insulation and more efficient appliances; higher prices[16] and the recession; or changes in the building stock and household composition.

Figure 3.4: Median gas and electricity consumption (kWh), 2005 to 2014



The fall in median consumption is seen consistently across all property types, household characteristics, geographies and socio-demographic classifications. However, certain

[15] The energy efficiency of the housing stock has improved between 2005 and 2014. The average SAP rating of a dwelling increased by 9.5 points from 49.0 in 2005 to 58.5 in 2012. The SAP rating is a measure of the overall energy efficiency of a dwelling. English Housing Survey Headline Report 2012-13, Annex Table 19: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/284649/Headline_Report...

[16] See Annex D for a discussion of the evidence of how gas price changes affect consumption levels

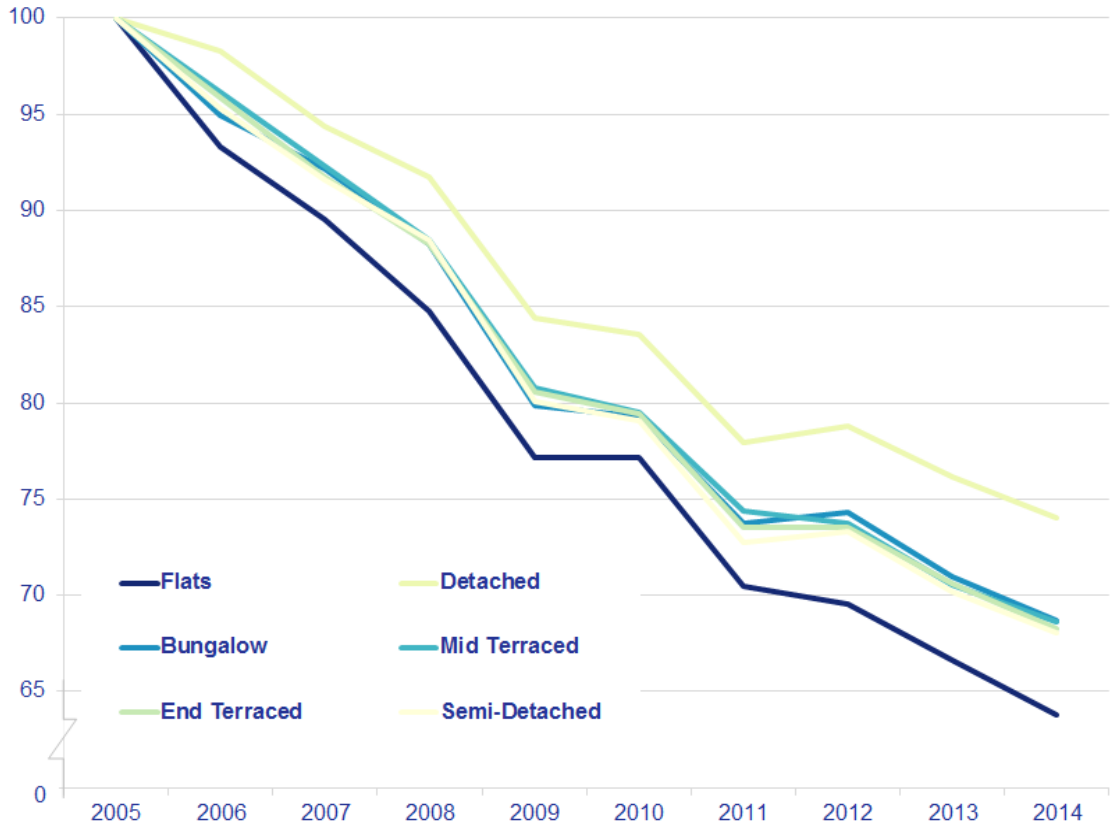
households will have been more or less affected by the different factors described above. The remainder of this section provides some highlights of changes over time for different property attributes and household characteristics. All changes in consumption are shown as an index relative to a 2005 baseline[17].

3.4 Trends in domestic consumption by property attributes

Figure 3.5 shows the trend in median gas consumption by property type. It demonstrates that between 2005 and 2014, the fall seen in overall consumption was evident among all property types. However, in general, smaller properties showed a greater percentage decrease in median consumption when compared with larger properties. For example, in 2014 typical gas consumption for flats was 36 per cent lower than in 2005, but for detached dwellings this reduction was only 26 per cent. The mid-size property types (bungalows, semi-detached and terraced) followed an almost identical pattern to each other.

[17] Note that the y-axis for these charts does not start at zero in order to allow differences between groups to be seen more clearly.

Figure 3.5: Percentage change in median gas consumption over time by property type (2005=100)



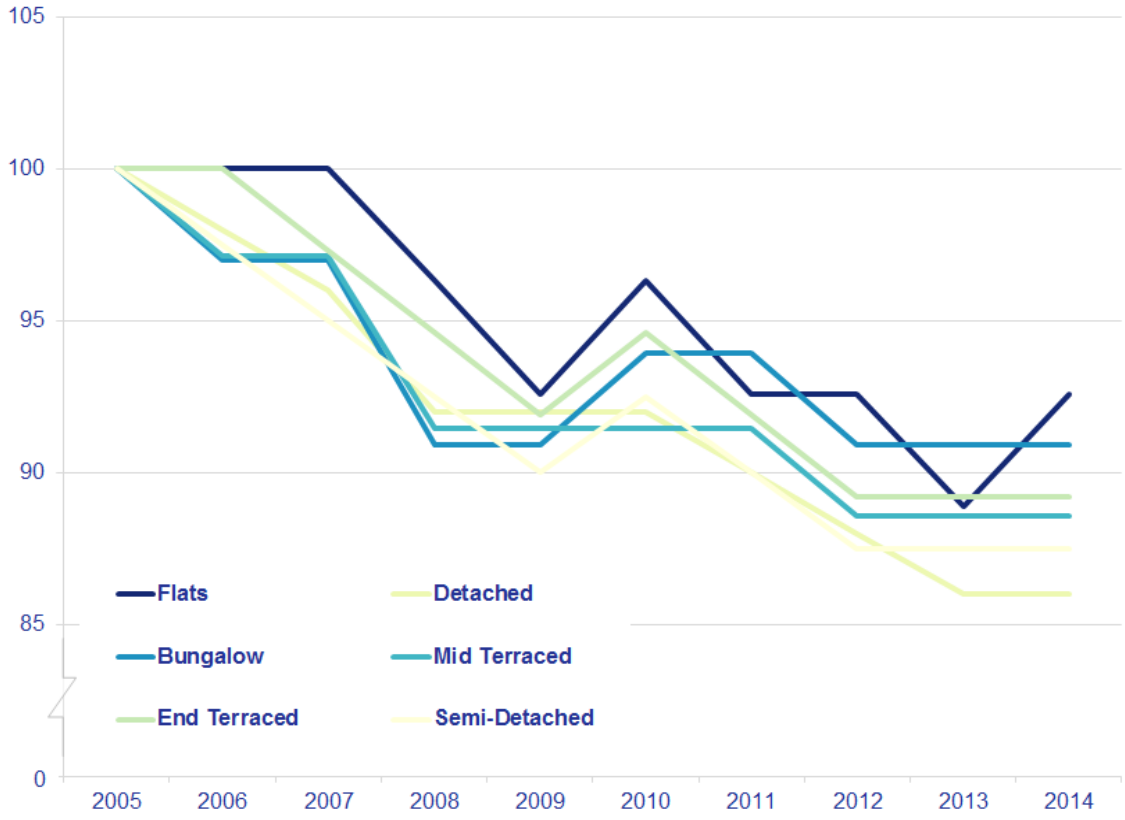
In contrast to gas consumption, where smaller property types showed the greatest decline, the reverse was apparent when looking at the equivalent pattern for electricity. Figure 3.6 shows that detached properties saw the largest decline in average consumption between 2005 and 2014 (14 per cent) while flats saw the smallest (7 per cent).

Analysis presented in Annex D indicates that increases in gas prices have made a notable contribution to the overall decline in domestic gas consumption seen over the last decade. Preliminary evidence within the annex also suggests that lower income households are more sensitive to price rises and reduce consumption to a greater extent, in response to a rise in price, compared to higher income households. As lower income households are more likely to live in smaller properties, this might explain why gas consumption has fallen faster in these categories. Meanwhile, electricity prices have not risen to the same extent as gas prices in recent years, which perhaps explains why the suspected price effect seen in Figure 3.5 is not apparent in Figure 3.6. There are, however, additional factors which may also have had some influence on the observed pattern. For instance a far higher proportion of small properties (particularly high-rise flats) use electricity for heating, compared to larger properties that predominantly use gas.

The increased volatility in Figure 3.6 compared to Figure 3.5 likely reflects the fact that, unlike gas, the electricity consumption figures are not weather corrected to adjust for

variation in the demand due to temperature and wind conditions. Around a fifth of properties are, however, off the gas grid and use alternative fuel sources, including electricity to heat their homes.

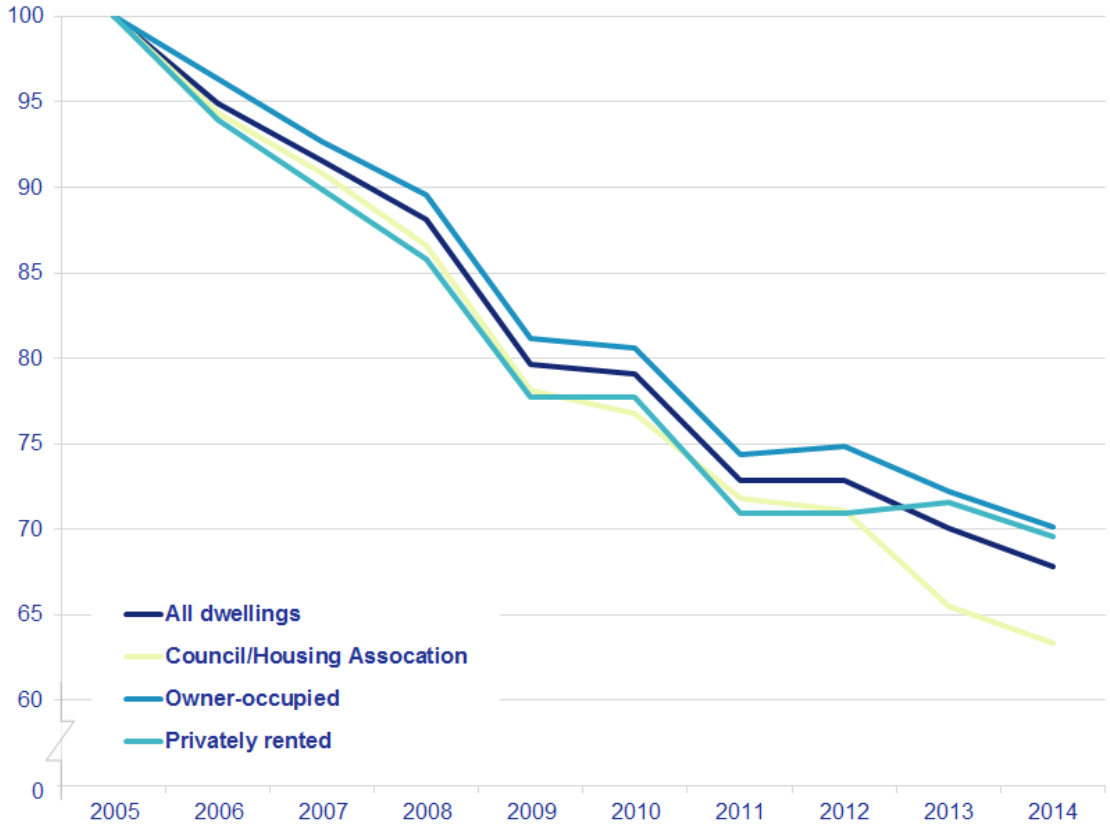
Figure 3.6: Percentage change in median electricity consumption over time by property type (2005=100)



3.5 Trends in domestic consumption by household characteristics

Figure 3.7 shows the trend in consumption of gas since 2005 split by tenure. Over this time council/housing association properties have consistently exhibited a faster decline in consumption when compared to owner-occupied properties. Until 2012, consumption in the private rented sector followed a very similar pattern to the social housing sector, but in the last couple of years switched to a path more similar to owner-occupied properties.

Figure 3.7 Percentage change in median gas consumption over time by tenure (2005=100)



4. Impact of energy efficiency measures in homes

4.1 Background

This chapter analyses the impact of installing energy efficiency measures on a household's gas consumption, in England and Wales[18]. The energy efficiency measures included in this section are:

- cavity wall insulation;
- loft insulation;
- condensing boilers; and
- solid wall insulation.

Installing a combination of these measures has also been explored.

Analysis has also been conducted on the effect that installing solar photovoltaic[19] (solar PV) panels through the Feed-In Tariffs scheme has on mains **electricity** consumption.

The Green Deal (GD)[20] and Energy Company Obligation (ECO) were launched in 2013 with both schemes aiming to reach properties that previous Government schemes did not, by tackling a number of key barriers to the take-up of energy efficiency measures (Green Deal) and providing measures to low-income and vulnerable consumers, and those living in 'hard to treat' properties (ECO). A continuing emphasis on energy efficiency means it remains important to understand how these measures impact on a household's gas and electricity use, both to help understand the impact of past policy and help with the effective design of new policies.

[18] The impact of installing cavity wall insulation and loft insulation in Scotland are analysed in Annex B.
[19] Please note that the electricity consumption savings made by installing a solar PV panel cannot be compared with the gas consumption savings made by installing one of the energy efficiency measures listed above.
[20] This includes Finance Plans, Cashback and GD Home Improvement Fund. Further information and statistics covering GD/ECO are available at: https://www.gov.uk/government/collections/household-energy-efficiency-national-statistics.

Results presented in this section refer to the savings in households' gas consumption. All gas consumption data are presented on a weather corrected[21] basis – which means that the consumption for each household has been adjusted to account for differences in temperature and wind each year. Estimates are based on observed savings, so they are savings after 'comfort taking'[22] and do not take into account the quality or coverage of the energy efficiency measure being installed. For example, estimates could include some properties which have only had cavity wall insulation installed in three of their four walls. This means that individual households have the potential to make a greater saving than the results presented in this report. There is also the potential for households to make smaller savings than those presented here, since there are a number of factors that can impact the amount of gas a household consumes (for example, a change in occupants[23]).

The method used compares the gas consumption in properties before and after an energy efficiency measure is installed with the change in consumption over the same period for similar properties which have not had a measure installed.

To do this, intervention and comparator groups are created – with the intervention group containing properties which have received the energy efficiency measure being considered (and no other measure), and the comparator group containing similar properties that have not had a recorded energy efficiency measure installed at any point[24]. The changes in Government schemes and the increased number of measures included in the analysis this year reduced the number of records in the treatment and comparison groups compared to previous analyses, resulting in very few (or in some cases no) records for smaller breakdowns. Therefore, results for 2013 have been boosted by using all records of installations from the entire NEED dataset instead of the sample[25].

[21] An overview of the weather correction of gas industry consumption data can be accessed here: https://www.gov.uk/government/statistics/overview-of-weather-correction-of-gas-industry-consumption-data.
[22] Comfort taking is where some households take the benefit of the insulation measure through increased warmth rather than entirely through energy saving. For example, a household may have had their thermostat set lower than they wanted in order to lower their gas use, but after installing an energy efficiency measure they could choose to increase the temperature on their thermostat and use the same amount of energy since their property should now retain the heat better than before due to the improved energy efficiency.
[23] Analysis looking at the impact of a change in occupancy upon household gas consumption has been explored in Annex C of the 2015 NEED publication, which can be accessed here: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/437099/Annex_C_Change_of_occupancy_analysis.pdf.
[24] This group has no energy efficiency measure recorded as being installed in HEED, Green Deal, ECO or FiTs. These properties may have a measure installed which has not been recorded in any scheme, for example the homeowner installing their own loft insulation. It should be noted that - with the exception of professional loft insulation - it is equally possible that properties in the intervention group could have installed their own loft insulation, and this will also not be recorded.
[25] Further details about the methodology used in the impact of measures analysis can be found in the NEED methodology note: https://www.gov.uk/government/statistics/domestic-national-energy-efficiency-data-framework-need-methodology.

Results cover the installation of energy efficiency measures over the period 2005 to 2013. A more detailed explanation of the methodology used can be found in the Domestic NEED methodology note: https://www.gov.uk/government/publications/domestic-national-energy-efficiency-data-framework-need-methodology. Flats are excluded from both the comparison and intervention groups due to insufficient address information. Properties built post-1999 are not included in the cavity wall and loft insulation analysis, due to a change in building regulations[26] and the requirement for all properties to have loft insulation and cavity insulation as standard as of that date.

All headline figures in this report refer to weighted figures; i.e. the savings have been adjusted to be representative of the complete housing stock rather than just the properties which have had the measure installed through a Government scheme in the year under consideration (the intervention group). The estimates set out in the rest of this section provide insight into the range of savings experienced and how typical savings vary for different types of properties and households. A negative figure indicates the observed saving in consumption for the intervention group following the installation of an energy efficiency measure, compared to the comparator group

The Domestic Energy Consumption section of this report (Chapter 3) presents gas and electricity consumption figures for the representative NEED sample which can help to put results in this section into context. The headline results are presented below and can also be found in Annex F with additional summary statistics.

4.2 Impact of installing a single energy efficiency measure

This section presents headline results and key findings for the impact of installing a single energy efficiency measure in a household in 2013. Table 4.1 below shows the median savings experienced in gas consumption for properties having the following installations in 2013:

- cavity wall insulation – typical savings for properties installing cavity wall insulation were 8.4 per cent (representing a saving of 1,200 kWh).
- loft insulation – typical savings of 2.1 per cent (300 kWh).
- condensing boilers – typical savings of 8.3 per cent (1,200 kWh).
- solid wall insulation[27] – typical savings of 15.5 per cent (2,000 kWh).

[26] Further information about building regulations can be found in Annex G of this publication.
[27] All figures on solid wall insulation should be interpreted with care since they are based on a much smaller number of records and a less diverse housing stock than other energy efficiency measures presented in this

The impact of installing solar PV showed typical median savings in mains **electricity** consumption of 10.6 per cent (500 kWh).

Further information about each energy measure is provided below. Additionally, looking at the savings made by property type provides an opportunity to identify the typical property characteristics which seem to benefit the most from having a particular energy efficiency measure installed. Detailed data tables including breakdowns by property attributes and household characteristics are published in Annex F. A few examples are provided in the following section of how the type of property can help to explain the savings shown.

Cavity wall insulation by property type

In 2013, two thirds (67 per cent) of cavity wall insulation installations included in the intervention group were in three bedroom properties. For context about half of the properties (48 per cent) in the NEED sample have three bedrooms[28]. In addition the most common type of property in the NEED sample are three-bed semi-detached properties, making up 20 per cent of the sample.

report. For example, in this analysis the number of households with solid wall insulation installed in 2013 was 3,060. This is compared to 21,730 households with cavity wall insulation installed.

[28] Based on all properties which have valid electricity consumption in 2014.

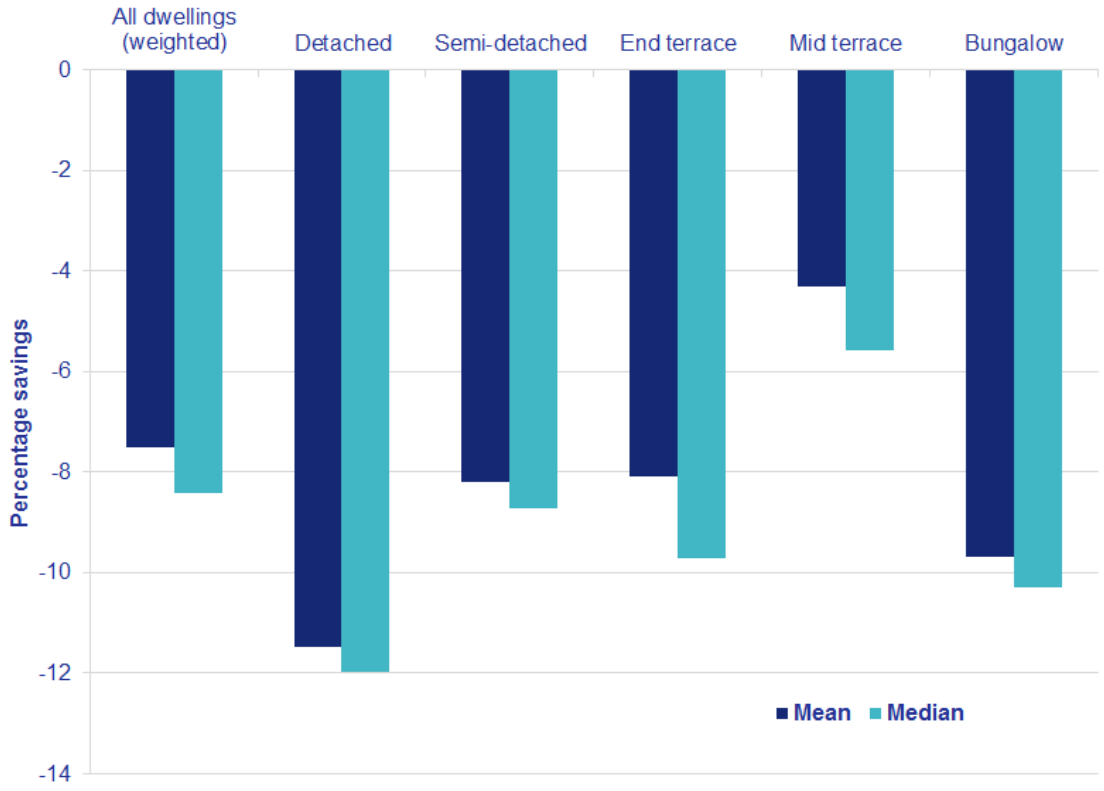
Table 4.1: Summary of observed savings (weighted) – single energy efficiency measure installed in 2013

Energy efficiency measure		Percentage saving	Saving (kWh)[1]
Cavity wall insulation	Median	-8.4%	-1,200
	Mean	-7.8%	-1,300
Loft insulation	Median	-2.1%	-300
	Mean	-1.9%	-400
Condensing boiler	Median	-8.3%	-1,200
	Mean	-7.0%	-1,300
Solid wall insulation	Median	-15.5%	-2,000
	Mean	-14.0%	-2,100
Solar PV panel[2]	Median	-10.6%	-500
	Mean	-8.3%	-400

(1) Savings in consumption have been rounded to the nearest 100 kWh.
(2) Savings in installing solar PV are reported for electricity consumption – unlike cavity wall, loft insulation, condensing boilers and solid wall insulation which report savings in gas consumption.

Figure 4.1 below shows the observed percentage savings in gas consumption for three-bedroom properties installing cavity wall insulation in 2013 by property type. It shows that when looking at three-bedroom properties, detached properties experienced the greatest typical saving, with mid-terrace properties seeing the smallest reduction in gas consumption – this pattern has remained unchanged since the 2012 results. It is to be expected that mid-terrace properties would see the smallest savings since they only have two external walls, whereas detached, semi-detached and end-terrace all have at least three.

Figure 4.1: Observed savings (weighted) in gas consumption for three bedroomed properties having cavity wall insulation installed in 2013, by property type

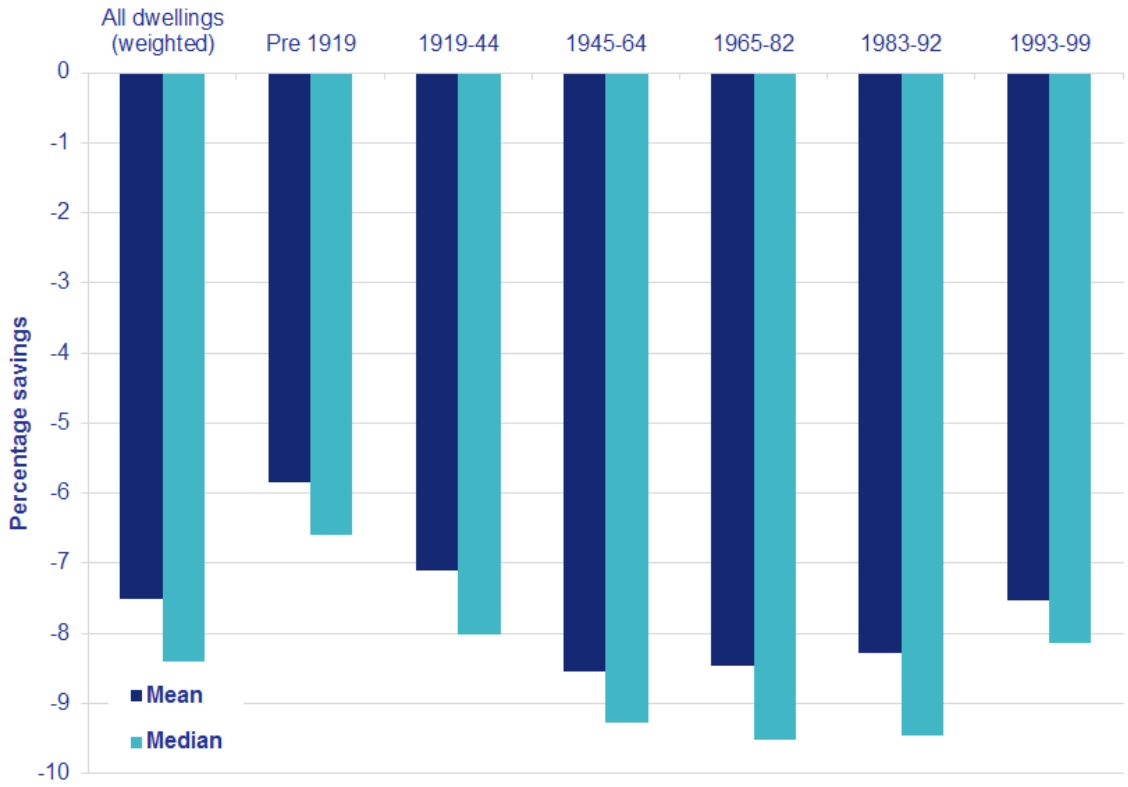


Footnotes:
1. Consumption data from sub-national gas and electricity consumption statistics 2014, https://www.gov.uk/government/organisations/department-of-energy-climate-change/about/statistics
2. Household characteristics data sourced from the Valuations Office Agency as at April 2016

Figure 4.2 shows the observed percentage savings in gas consumption by property age. It shows an overall trend in newer properties experiencing the greatest savings from having cavity wall insulation installed. This could be due to changes in building materials used to meet building regulations[29], which impacts the effectiveness of installing an energy efficiency measure.

[29] Further information about building regulations can be found in Annex G of this publication.

Figure 4.2: Observed savings (weighted) for properties having cavity wall insulation installed in 2013, by property age



Footnotes:
1. Consumption data from sub-national gas and electricity consumption statistics 2014, https://www.gov.uk/government/organisations/department-of-energy-climate-change/about/statistics
2. Household characteristics data sourced from the Valuations Office Agency as at April 2016

Loft insulation

Loft insulation installations included in this analysis cover installations into lofts which had no insulation (virgin loft insulation), and installations into lofts which were already partially insulated (top-up loft insulation). Therefore, households with very little or no existing insulation can expect to save more than the typical savings outlined. Conversely, properties which already have a reasonable amount of loft insulation, or where the existing insulation is being replaced, are likely to experience smaller savings.

It is also possible that these figures slightly underestimate savings because of the potential for DIY loft insulation to be installed in the comparator group, but not in the intervention group. This will mean the comparator group may have experienced some savings as a result of insulation which is not accounted for in the intervention group.

Condensing boiler

The Energy Company Obligation (ECO), which was launched in 2013, provides grants for eligible households to replace boilers that are over ten years old. The proportion of boilers installed in older properties, which are more likely to have older boilers, was consequently

higher in 2013 compared to previous years. Due to this skewed installation pattern, the difference between the weighted and un-weighted savings for boilers is more pronounced. This should be taken into consideration when interpreting the weighted results. Un-weighted results and breakdowns of savings by property age, and other characteristics, are available in the accompanying tables in Annex F.

Data for boiler installations prior to 2009 are not available and therefore historical data have not been included within this publication.

Solid wall insulation

There are approximately 3,060 properties included in the impact of a single measure section of this report (for comparison, loft insulation results for 2013 are based on 19,530 measures). There are a number of reasons for this reduced sample size, the first being that not as many properties have received this measure compared to others. In addition, properties which had solid wall insulation are more likely to be excluded from the analysis in NEED. Firstly, solid wall insulation is often installed in flats which are excluded from the impact of measures analysis due to difficulties with matching information to the correct flat within a building and therefore to the correct annual consumption. Secondly, solid wall insulation is often installed in properties which do not have gas as the main heating fuel, and therefore these properties could not be included in this analysis, since record-level consumption data are not available for non-metered fuels. Finally solid wall insulation is often installed in combination with another energy efficiency measure, such as a new boiler or loft insulation, and so these properties could not be included in the analysis of the impact of solid wall insulation on its own. When interpreting the results for solid wall insulation installed in 2013, the small number of properties should be taken into account.

The typical (median) annual percentage saving for solid wall insulation in 2013, when weighted to be representative of the housing stock, was 15.5 per cent (2,000 kWh). The mean saving seen was 14.0 per cent (2,100 kWh).

Continued research is also being carried out by DECC in the field to improve understanding of the performance of solid wall properties in the UK housing stock and the effect on energy post-insulation. The research investigates heat losses through solid walls and other parts of the dwelling, before and after insulation, with the intention to improve models of solid wall dwellings, understand the unintended consequences of solid wall insulation, and improve tools for assessing the energy savings from solid wall properties[30].

Solar Photovoltaic (PV)

[30] Further information can be accessed at: https://www.gov.uk/government/publications/solid-wall-heat-losses-and-the-potential-for-energy-savings-literature-review

DECC introduced the Feed-in Tariff (FIT) scheme in April 2010 to promote the deployment of a range of small-scale low-carbon electricity generation technologies in Great Britain. The FIT scheme subsidises solar PV, hydro, wind, anaerobic digestion installations below 5 MW, and micro combined heat and power below 2 kW. Microgenerators receive guaranteed payments from electricity suppliers based on the amount of electricity produced, along with export tariffs for electricity not used on-site but fed ('exported') to the grid. Unless the microgenerator installs a second electricity meter specifically for exports, 50 per cent of the electricity generated is deemed to be used on-site, and the other 50 per cent, exported to the grid, and export payments are made accordingly. For more information about the FIT scheme, please visit www.ofgem.gov.uk/environmental-programmes/feed-tariff-fit-scheme. Alternatively, further information has been provided in Annex B of the 2015 publication[31]

The effect on a households mains electricity consumption after installing solar PV has been explored in this chapter. This differs to the energy efficiency measures included in this chapter, where gas consumption is examined.

4.3 Impact of installing a combination of energy efficiency measures

This section looks at the impact of installing a combination of energy efficiency measures. The combinations of measures considered in this section are:

- cavity wall insulation and loft insulation;
- cavity wall insulation and a boiler;
- solid wall insulation and loft insulation;
- loft insulation and a boiler; and
- cavity wall insulation, loft insulation and a boiler.

The limitations of the data sources as outlined in the section on the impact of a single measure also apply to data used for the analysis set out in this section. Combinations involving solid wall and a condensing boiler; and solid wall insulation, loft insulation and a boiler have not been presented in this section due to the small number of households in these two groups. Solar PV has also not been included in this section as savings are based on electricity consumption and cannot be compared with the savings in gas

[31] Annex B of the 2015 NEED publication can be accessed here: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/437097/Annex_B_Electricity_use_in_households_with_solar_PV_panels.pdf.

consumption achieved by installing one of the other measures (cavity wall insulation, loft insulation, a condensing boiler or solid wall insulation).

Table 4.2 below summarises the median and mean percentage and kWh savings experienced in gas consumption when installing a combination of energy efficiency measures in the same year. Headline figures presented are weighted to be representative of the complete housing stock, rather than just the properties which had the combination of measures installed in the year under consideration. Table 4.2 shows that the greatest savings can be made by installing cavity wall insulation, loft insulation and a condensing boiler (20.1 per cent), followed by solid wall and loft insulation (18.5 per cent).

In all but two (cavity wall insulation and a boiler; and loft insulation and a boiler) of the combinations of measures, the saving from installing the measures in combination are slightly higher than the sum of the savings for each individual measure. For example, for the consecutive installation of cavity wall insulation and loft insulation the percentage saving in consumption is 10.9 per cent (Table 4.2). If the installation of cavity wall insulation and loft insulation occur separately the estimated typical savings are 8.4 per cent (cavity wall) and 2.1 per cent (loft insulation). These savings sum to 10.5 per cent, which is lower than the difference shown in Table 4.2 for the installation of both measures in the same year.

Table 4.2: Summary of observed savings (weighted) – combinations of energy efficiency measures installed in 2013

Energy efficiency measure		Percentage saving	Saving (kWh)[1]
Cavity wall insulation, loft insulation	Median	-10.9%	-1,500
	Mean	-9.8%	-1,600
Cavity wall insulation, boiler	Median	-16.2%	-2,400
	Mean	-13.9%	-2,600
Solid wall insulation, loft insulation[2]	*Median*	*-18.5%*	*-2,200*
	Mean	*-16.2%*	*-2,400*
Loft insulation, boiler	Median	-9.3%	-1,300
	Mean	-8.1%	-1,500
Cavity wall insulation, loft insulation, boiler[2]	*Median*	*-20.1%*	*-3,000*
	Mean	*-18.3%*	*-3,400*

(1) Savings in consumption have been rounded to the nearest 100 kWh.

(2) Care should be exercised when interpreting these figures, as these are based on a small number of households. The combinations of: solid wall and a boiler; and solid wall insulation, loft insulation and boiler have not been included as the number of households were very small.

4.4 Sustainment of energy efficiency measures

The impact of measures analysis primarily compares gas consumption in the year before and after installation of an energy efficiency measure to get an estimate of the annual saving from installing energy efficiency measures[32]. The annual difference in consumption for the intervention and comparator groups was considered for cavity wall insulation and loft insulation installed in each year between 2005 and 2008 to analyse whether the savings observed in the year immediately after installation of an energy efficiency measure continue. The analysis for condensing boilers covers 2009 to 2013 only due to the lack of historical data, and analysis for solid walls has not been included in this section.

The longer time series analysis has been carried out using the same methodology as the 2013 analysis. For example, when looking at the effect of installing cavity wall insulation in 2005, the intervention group includes all properties with a cavity wall insulation installation

[32] All figures presented in this section are weighted to be representative of the housing stock rather than just properties which had each respective measure installed.

in 2005 with no other measures installed at any time. Similarly the comparator groups also exclude any installations at any point in time.

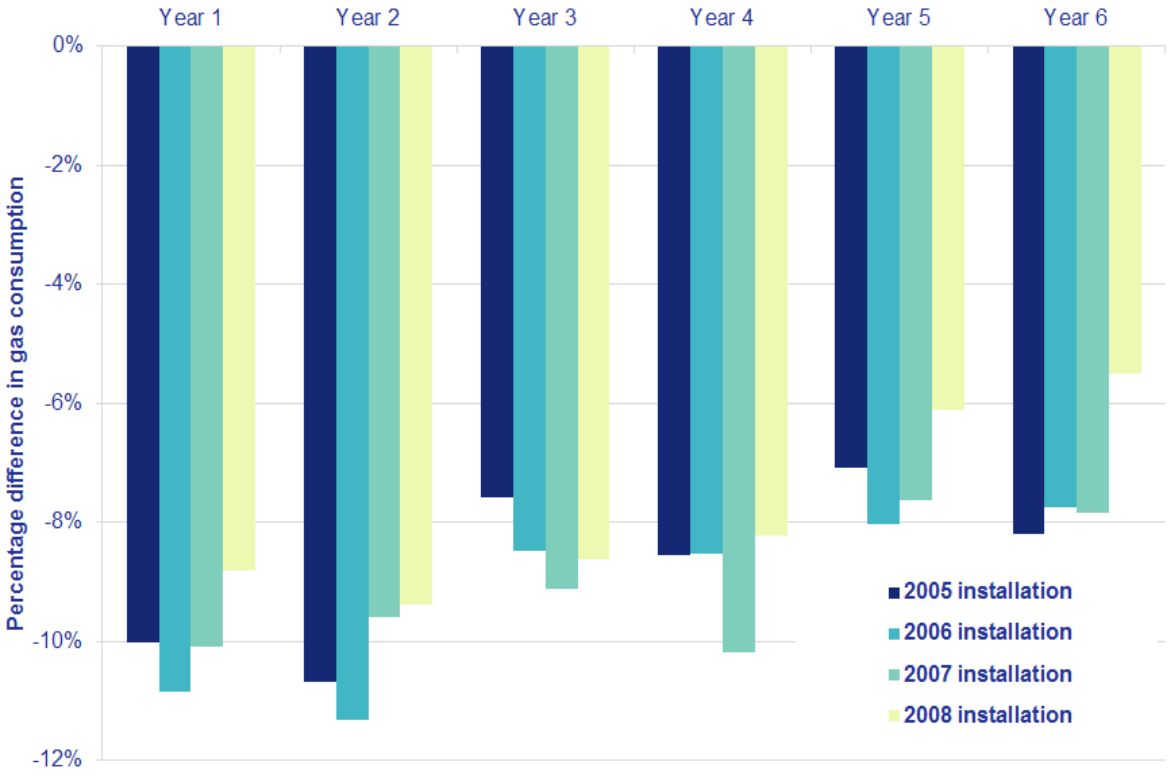
Cavity wall insulation

Figure 4.3 shows the percentage difference in gas consumption between the intervention and comparator groups for properties installing cavity wall insulation between 2005 and 2008. The biggest difference in median gas consumption is consistently seen in the first few years immediately after installation of cavity wall insulation (years 1 to 4 in Figure 4.3).

For each of the six years looked at, properties which had cavity wall insulation installed typically used around ten per cent less gas than similar properties which did not have a measure installed, in the year immediately after installation of the measure. In each of the four years considered, the overall gap between gas consumption for the two groups then reduces over time, though as demonstrated by Figure 4.3 it does not follow an entirely consistent pattern.

As consumption data are available up to 2014 and measures installed were considered between 2005 and 2008 it is possible to compare the savings for these three groups six years after installation of the measure. Properties which had cavity wall insulation installed in either 2005, 2006, 2007 or 2008 were typically using between five to eight per cent less gas than the comparator group of similar properties five years after installing the energy efficiency measure.

Figure 4.3: Percentage difference in gas consumption between the intervention and comparator groups for properties installing cavity wall insulation between 2005 and 2008



Footnotes:
1. Consumption data from sub-national gas and electricity consumption statistics 2014, https://www.gov.uk/government/organisations/department-of-energy-climate-change/about/statistics

Table 4.3 shows the percentage savings in gas consumption after having cavity wall insulation installed in each year between 2005 and 2013.

Table 4.3: Summary of percentage savings (weighted) in gas consumption between the intervention and comparator groups for properties installing cavity wall insulation between 2005 and 2013

Year of Installation	Percentage savings in gas consumption after installation								
	1 year	2 years	3 years	4 years	5 years	6 years	7 years	8 years	9 years
2005	-10.0	-10.7	-7.6	-8.5	-7.1	-8.2	-7.5	-8.5	-7.7
2006	-10.8	-11.3	-8.5	-8.5	-8.0	-7.7	-7.9	-7.2	
2007	-10.1	-9.6	-9.1	-10.2	-7.6	-7.8	-7.9		
2008	-8.8	-9.4	-8.6	-8.2	-6.1	-5.5			
2009	-8.9	-8.3	-7.3	-7.9	-8.3				
2010	-9.8	-7.4	-6.5	-6.0					
2011	-9.6	-7.7	-6.9						
2012	-8.4	-9.5							
2013	-8.4								

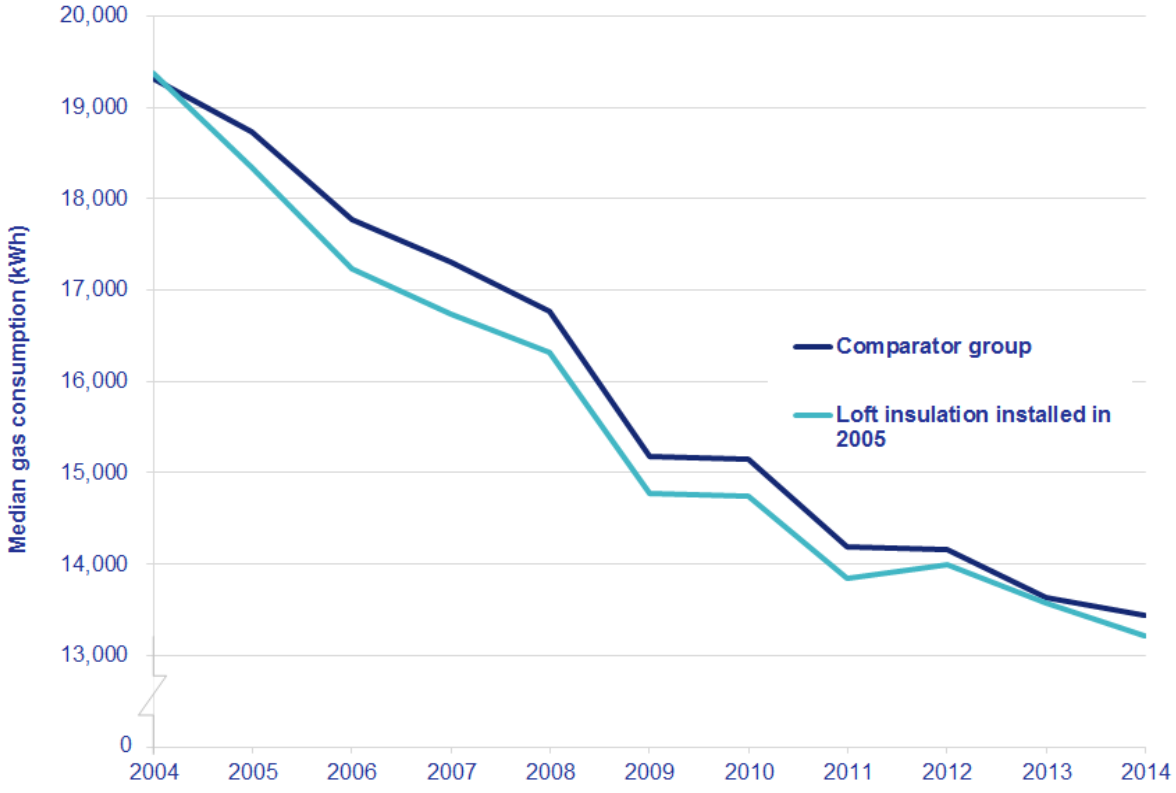
Overall the greatest reductions in consumption occur in the first and second years after installation, however as can be seen in the table, there continue to be savings made several years after having cavity wall insulation installed.

It should be taken into consideration that there may be other factors which affect changes in consumption over time[33].

Loft insulation

When looking at loft insulation installed between 2005 and 2013 results follow less of a pattern. Figure 4.4 illustrates the median consumption for the intervention and comparator group for loft insulation installed in 2005.

Figure 4.4: Loft insulation installed in 2005, long term gas consumption (weighted)



Footnotes:
1. Consumption data from sub-national gas and electricity consumption statistics 2014, https://www.gov.uk/government/organisations/department-of-energy-climate-change/about/statistics

[33] For example, Annex C of the 2015 NEED publication explores the effect on household gas consumption following a change in occupancy, which shows an average annual decrease of 2,100 kWh in consumption, compared with a decrease of 600 kWh for the comparison group which had no change of occupancy. This annex can be accessed here: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/437099/Annex_C_Change_of_occupancy_analysis.pdf.

Figure 4.4 shows that the biggest differences (over three per cent) in median consumption for properties installing loft insulation in 2005 and the comparator group occurred in 2006 and 2007– the years immediately following installation. There was a two per cent saving in gas consumption nine years after installation of the energy efficiency measure.

In the analysis here, the median gas consumption the year before the installation of the energy efficiency measure is similar, as illustrated when looking at 2004 in Figure 4.4. This is because one of the variables used to select the comparator group was gas consumption in the year before the intervention was installed – to ensure the properties compared were as similar as possible. The consumption for the two groups then diverges in the year that the energy efficiency measure was installed.

Condensing boilers

Due to the lack of historical boiler data available, this section only considers gas consumption for properties having a boiler installed between 2009 and 2013. Results in this section should be treated as provisional as there may be properties within the control group which have a boiler installed prior to 2009.

Properties which had a boiler installed in 2009 were typically using 11 per cent less gas than the comparator group of similar properties four years after installation of the energy efficiency measure.

More detailed headline figures for the analysis contained in this chapter are available in Annex F. Additional data tables, including breakdowns by property attributes and household characteristics, are also available in Annex F.