Domestic energy fact file 2003

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L D Shorrock and J I Utley

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DOMESTIC ENERGY FACT FILE 2003

By
L D Shorrock and J I Utley

Summary

The purpose of this report is to gather together in one volume data on important trends related to domestic energy use, and in particular on the measures that have been taken to improve energy efficiency. Most of the tables relate to national totals and will be mainly of use to Government Departments and others interested in research or planning at that level. The report covers the period from 1970 (just before the first oil crisis) until 2001, the latest year for which most of the figures are available. There are nine sections:

Section 1	Presents an overview of the publication which is also available separately on the web.
Section 2	Provides an introduction that discusses domestic energy consumption in the context of overall energy consumption.
Section 3	Deals with fuel prices and household expenditure on energy.
Section 4	Is concerned with basic statistics on population, households and the characteristics of the housing stock (age, tenure, dwelling type and regional distribution).
Section 5	Presents information on the uptake of fabric insulation measures in the housing stock.
Section 6	Deals with hot water tank insulation and the use of instantaneous water heaters.
Section 7	Presents information on changes to the housing stock heat loss, heating systems, temperatures and energy use. It also considers changes in efficiency of heating systems. This section also looks at what would have happened to the energy use of the housing stock if energy efficiency improvements had not been introduced. It contains the main conclusions on the effectiveness of insulation, improvements in efficiency and the rising standards of service achieved within the housing stock and also presents a comparison of Standard Assessment Procedure ratings by year for the average home.
Section 8	Draws together the topics discussed in section 7 to illustrate the individual effects of rising levels of service, external temperature variations, improved insulation and improved heating efficiency and how these combine to determine domestic sector energy consumption.
Section 9	Considers the fuels used to meet the energy demand of the housing stock and carbon emissions which result from this fuel use. The primary energy consumption associated with the energy delivered to the housing stock is also addressed in this section. A final energy balance diagram draws together the various topics discussed in the report by showing the main energy flows related to the housing stock.

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1 Overview

Introduction

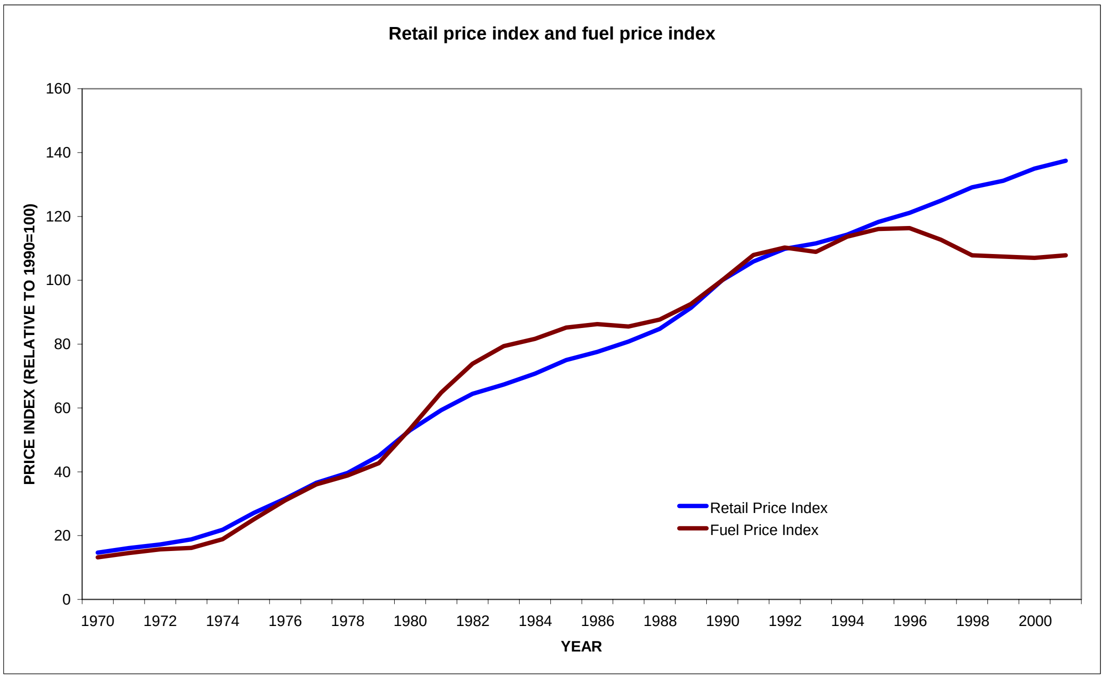
Domestic energy use represents a large proportion of total national energy use. It has risen from 25% of the total in 1970 to 30% in 2001. Clearly it is important to understand the drivers behind domestic energy use and the *Domestic Energy Fact File* is intended to fulfil that purpose by providing comprehensive information on relevant trends. This edition updates the main 1998 Fact File[1], presenting the most up to date information possible and introducing some completely new topics. The following overview highlights the main trends and findings of the report and concludes by indicating how the information that it contains has been used as the basis for further work addressing the prospects for the future.

The overview discusses key factors involved in domestic energy use. It considers the effect of fuel prices and rising numbers of households. It then looks at effects of improvements in insulation of dwellings and changes to heating systems including their efficiency. Changes in fuel use are examined and the carbon emissions from domestic energy use calculated. The information provides a means of looking at future as well as past trends and the overview ends by illustrating how this has been done.

Fuel prices

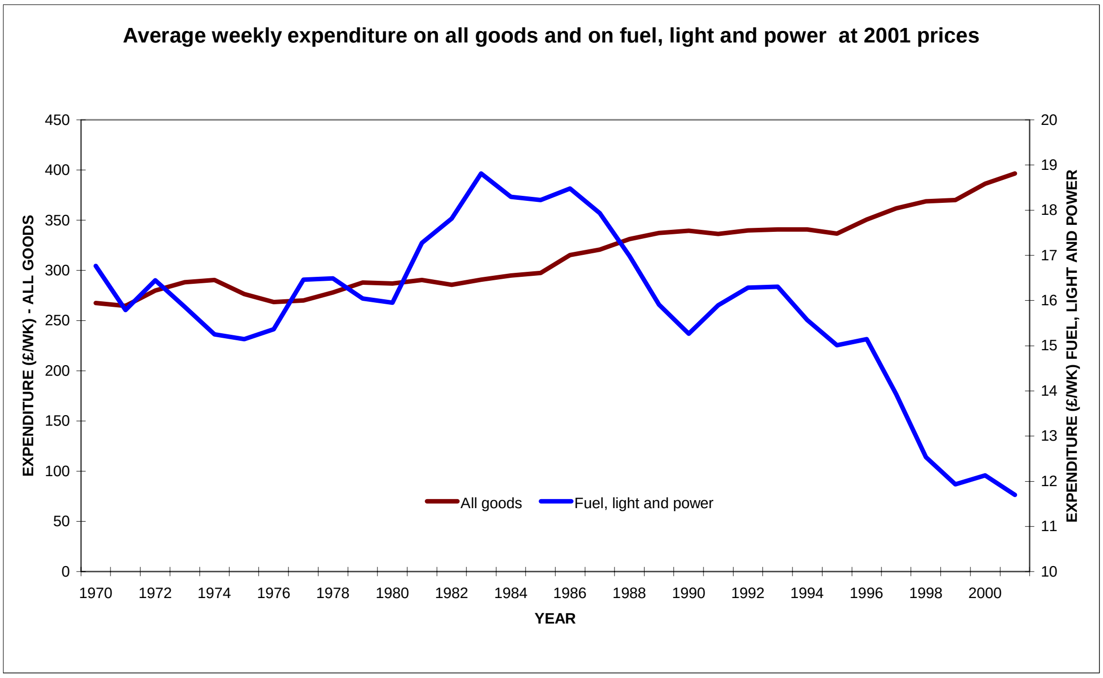
Until the mid 1990s, the fuel price index broadly increased in line with the retail price index, so the price of fuel in real terms was fairly constant. From the mid 1990s fuel prices have fallen in real terms.

Figure A



At the same time expenditure on all goods has increased fairly steadily, so the proportion that goes on fuel has diminished.

Figure B

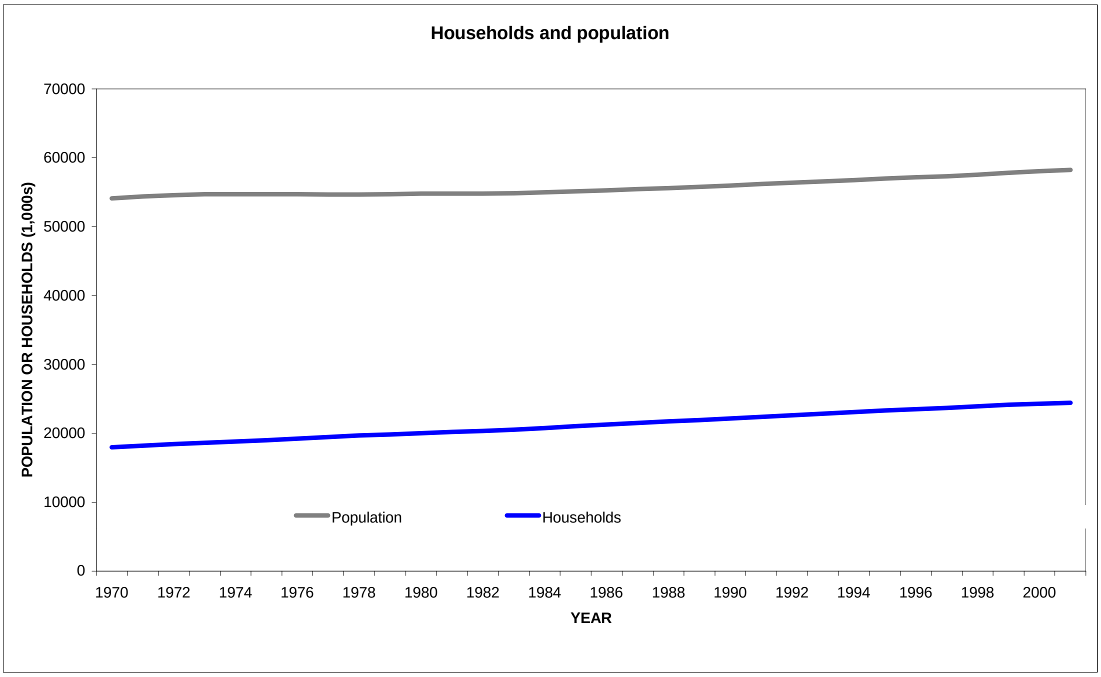


The lower fuel prices, however, have not resulted in a higher energy use. The average household energy use in 2001 was actually slightly lower than in 1970. This indicates that other factors must have been at work to improve the efficiency with which energy is used in the housing stock.

Household numbers and characteristics

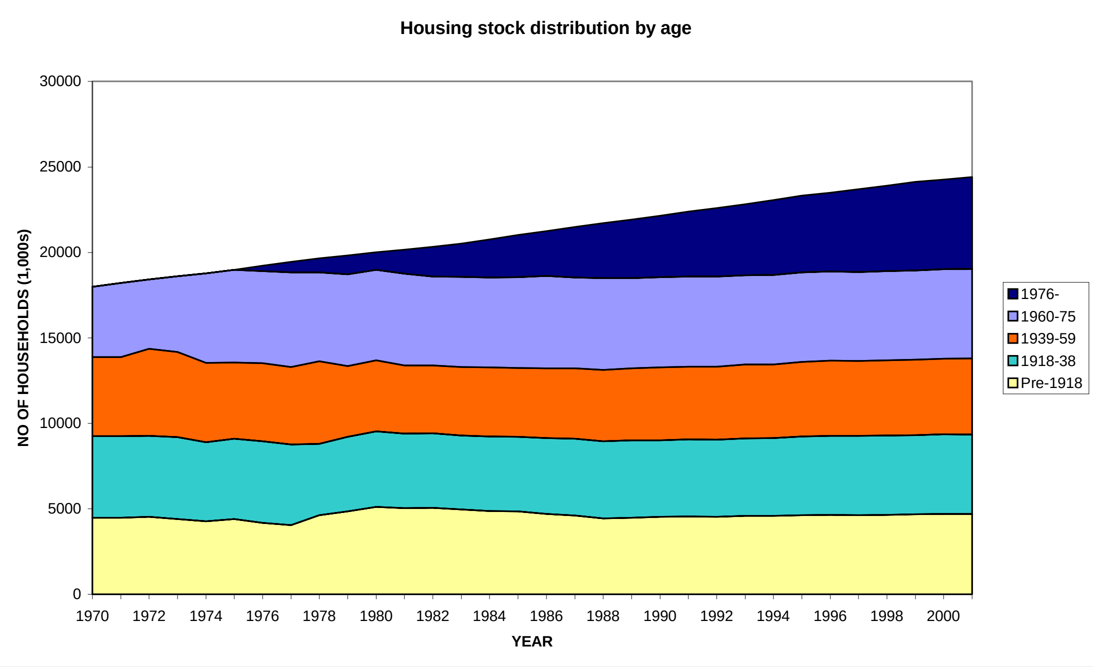
The number of households has been growing steadily at a faster rate than the population so the number of occupants per household has been reducing.

Figure C



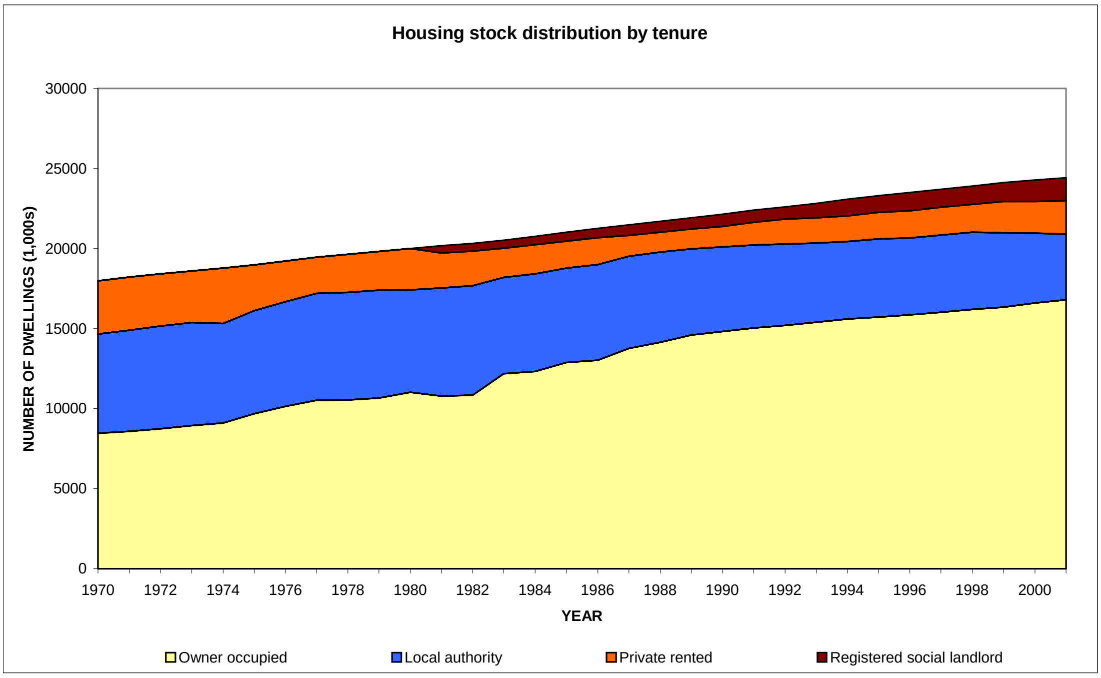
Both of these effects could be expected to increase the energy use of the housing stock. But there have been offsetting factors. Newer homes are built to higher energy efficiency standards so energy efficiency has been improving for that reason alone.

Figure D



Also there has been a strong move towards owner occupation, which tends to improve energy efficiency because it makes more people directly responsible for their homes.

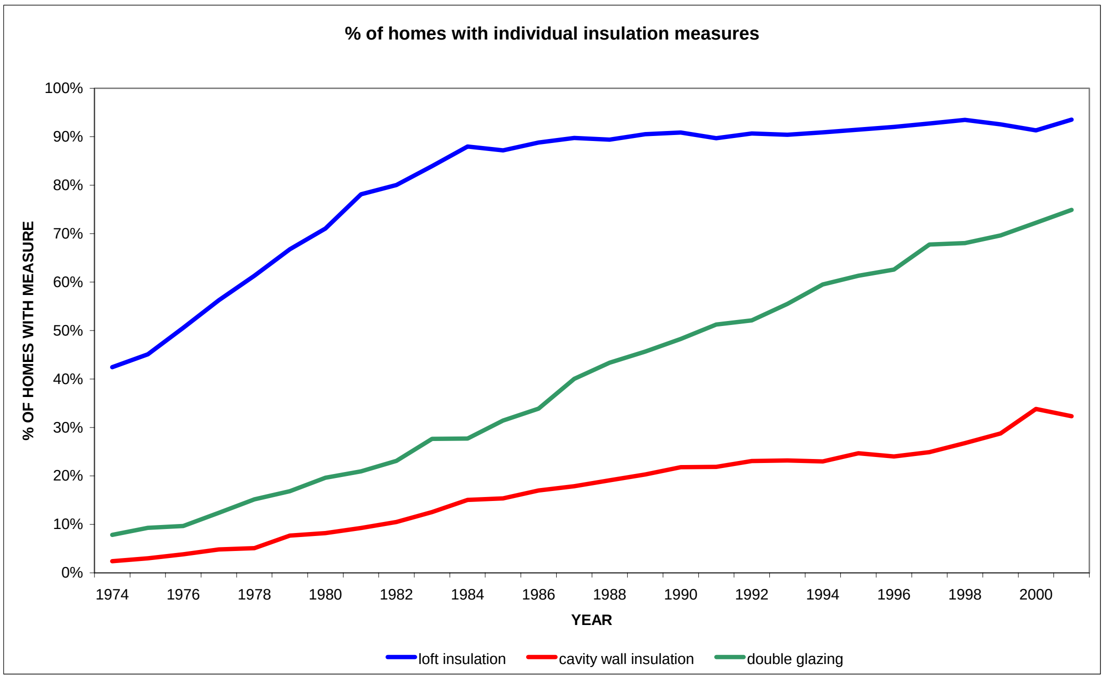
Figure E



Insulation improvements

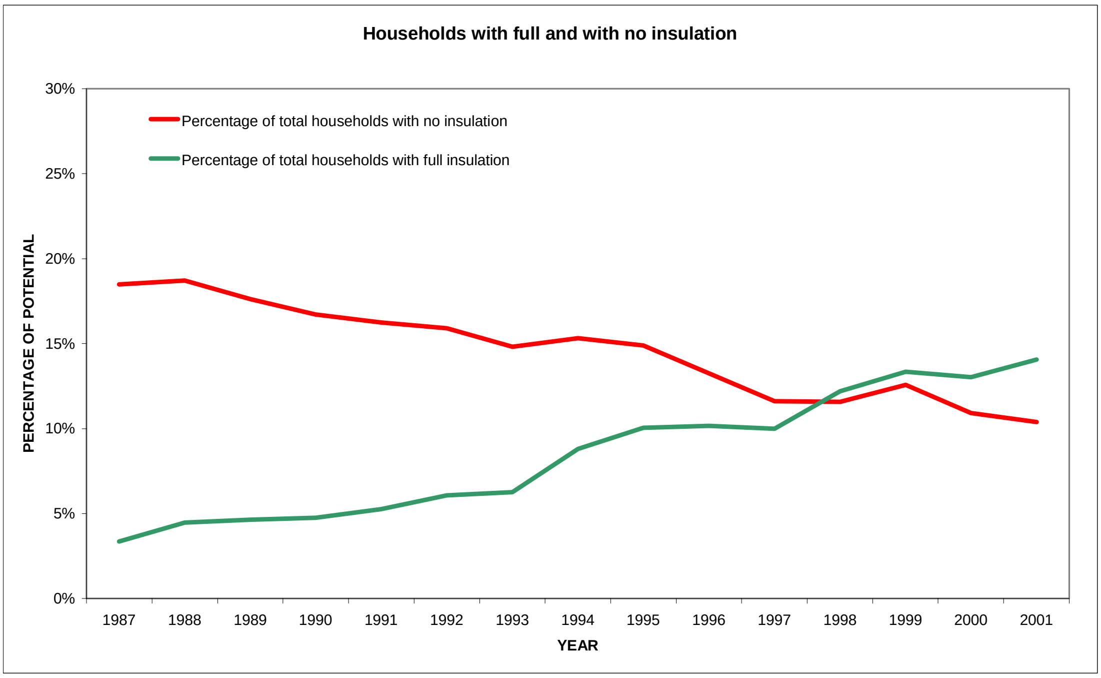
Insulation standards have increased quite dramatically. In 1974 only 42.5% of lofts and 2.4% of cavity walls were insulated and only 7.8% of homes had double glazing. By 2001, these figures had increased to 93.5%, 32.3% and 74.9% respectively.

Figure F



By 2001 only 10.4% of homes were completely un-insulated and the proportion with full insulation had grown to 14.1%

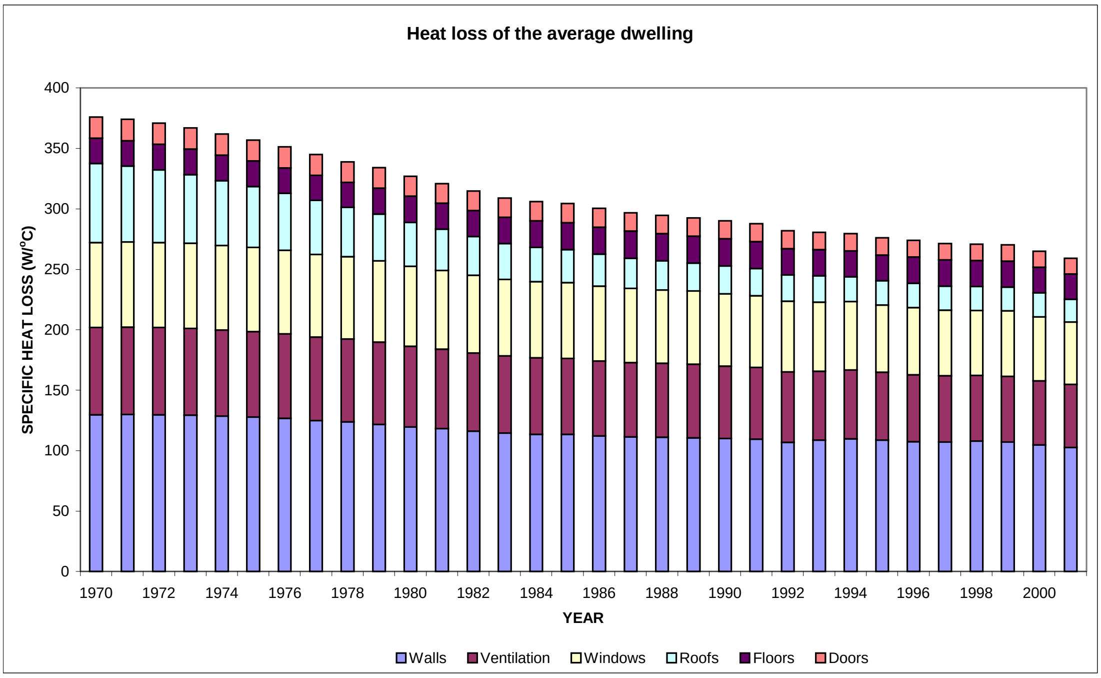
Figure G



Nonetheless these figures indicate that there is still a long way to go to further improve the insulation standards of the housing stock.

Overall the heat loss of the average dwelling reduced by 31% between 1970 and 2001.

Figure H

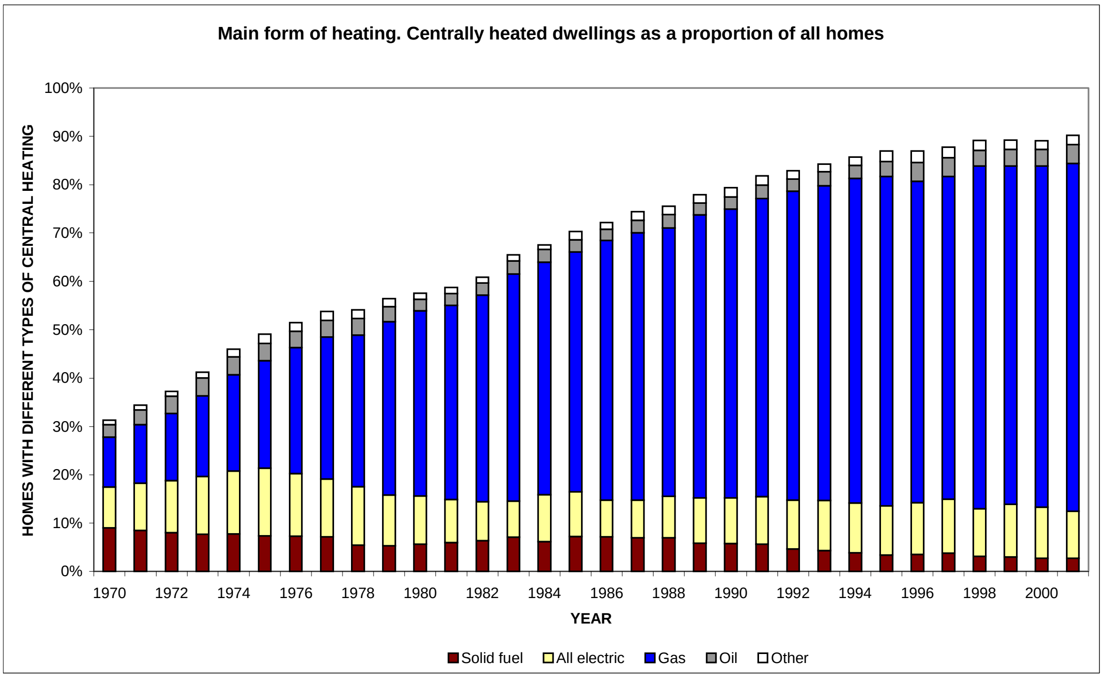


However, the heat loss of the entire stock has remained fairly constant since the early 1980s. This implies that the rate of improvement of the insulation standards of the stock is only just keeping pace with the tendency towards an overall larger heat loss due to the growth of the stock.

Heating standards and efficiencies

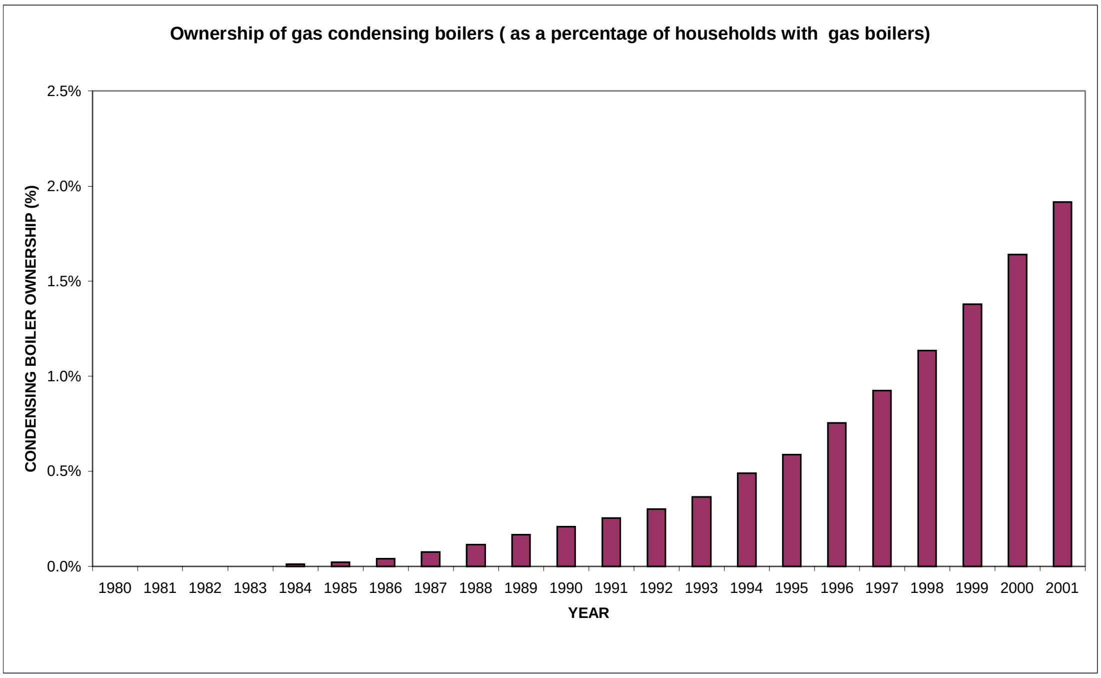
Expectations as regards heating standards have changed dramatically. In 1970 only 31% of homes had central heating. By 2001 this had risen to 90%. Most of this growth has been accounted for by gas central heating.

Figure I



This has led to both higher temperatures in homes – a rise of about 6°C in mean internal temperature between 1970 and 2001 – as well as higher heating efficiencies – estimated average efficiencies being 49% in 1970 and 70% in 2001. The trend towards higher efficiencies looks likely to continue as the popularity of condensing boilers grows and minimum standards imposed by the Boiler Efficiency Directive begin to have an effect.

Figure J

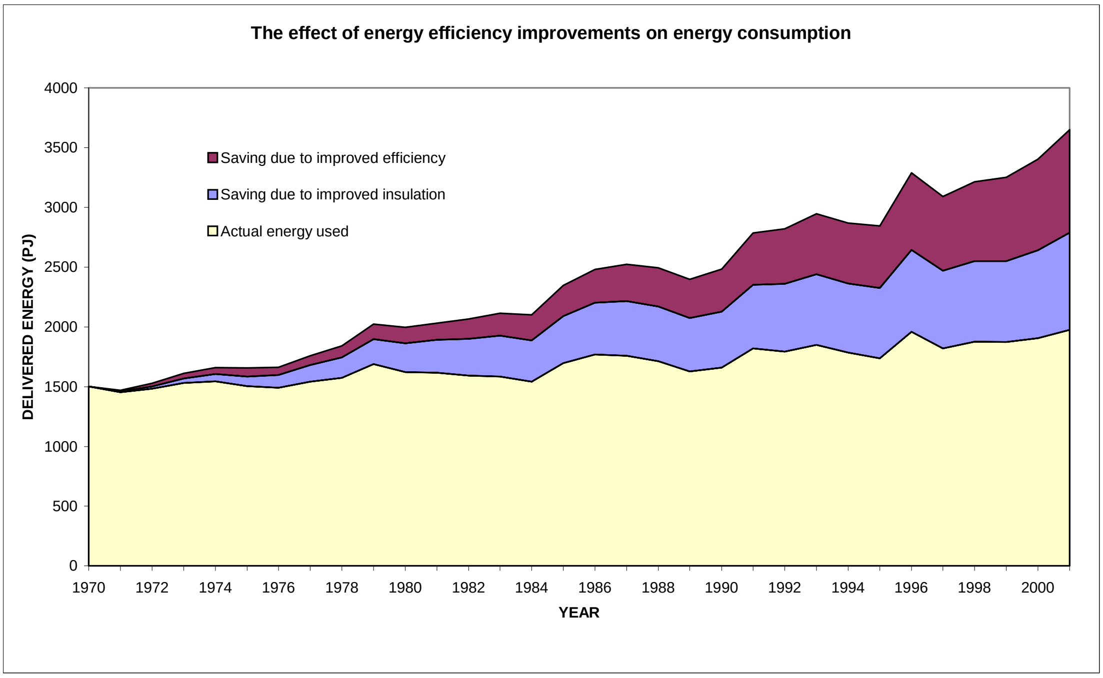


Overall increasing efficiencies appear to have countered the higher heating standards that have accompanied the growth of central heating – the average dwelling used almost the same amount of energy for space heating in 2001 as in 1970.

<u>The overall effect of energy efficiency improvements</u>

Using BREHOMES information it is possible to establish an energy balance for the housing stock for every year between 1970 and 2001. By assuming that the insulation and heating efficiency improvements had not happened the energy use that might have occurred can be estimated.

Figure K

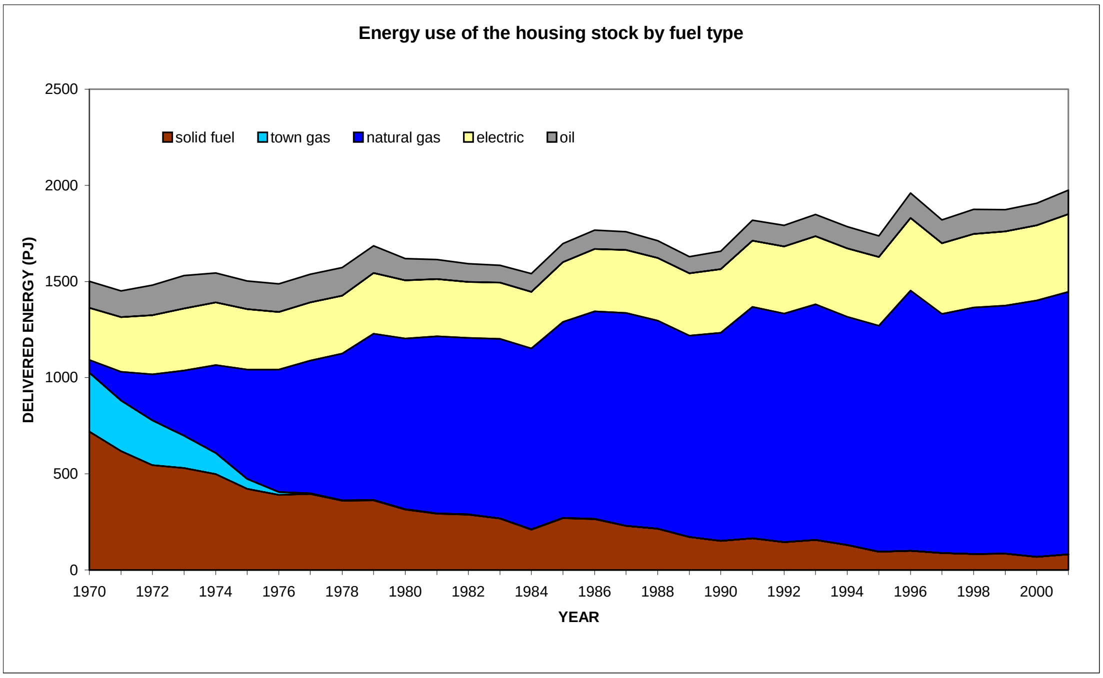


In 2001 this shows a saving of 46% relative to what the level of consumption might have been otherwise. Thus, energy efficiency has played a vital role in restraining the growth in housing stock energy use.

Actual housing stock energy use and carbon emissions

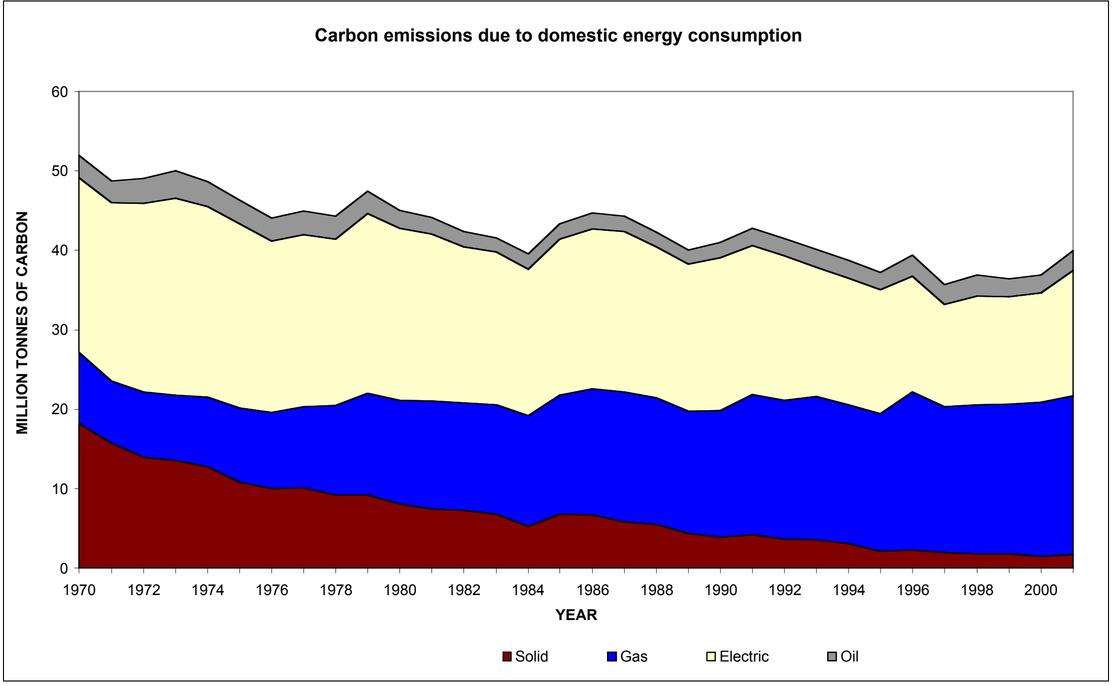
Overall, energy use in the housing stock has grown at a rate that is comparable with the increasing number of households (energy use increased by 31% between 1970 and 2001, whilst the number of households increased by 36%).

Figure L



So the average household energy use has not really changed very much. Despite this relative stability there have been major changes in the fuel mix, most notably the strong shift towards natural gas as the preferred fuel and the decline in the use of solid fuel. This has meant that carbon emissions due to housing stock energy use have reduced markedly.

Figure M



The future for housing stock improvements

Continued reductions in carbon emissions are required if the UK is to meet its commitments. The information contained in the *Domestic Energy Fact File* provides the basic material that is needed to assess the possible changes to carbon emissions from the housing stock in future.

Figure N

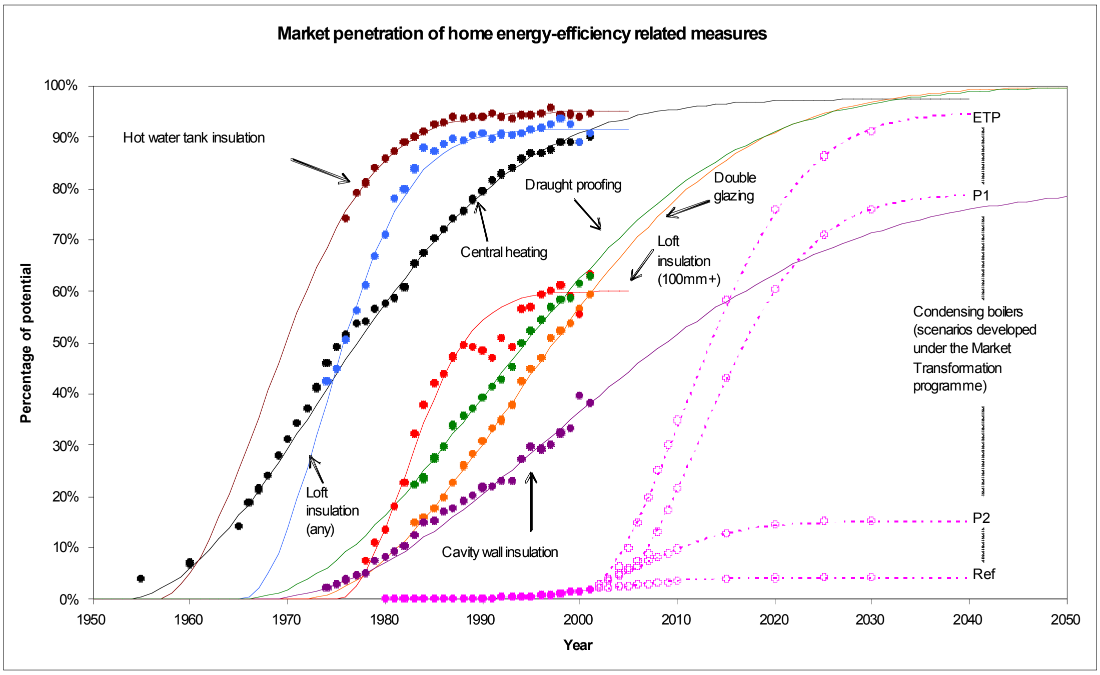


Figure N illustrates how the historical information can be used to establish market penetration s-curves that indicate likely future trends for individual measures. This shows, for example, that at present rates of growth, it might take until 2050 before cavity wall insulation is present in all homes for which it is suitable. It also demonstrates that even the fastest growing markets can take around 30 years to reach saturation. This indicates that there are no “quick fixes” when it comes to improving the energy efficiency of the housing stock. Scenario calculations based on this sort of information have been described elsewhere[2].

Note that the information shown in Figure N is in some cases not directly comparable with the raw information that is presented elsewhere in this report. For example, the double glazing data has been manipulated for Figure N such that it represents the proportion of windows in the stock that are double glazed rather than the proportion of homes in which some double glazing is present.

References

1. Domestic Energy Fact File 1998. G A Walters and L D Shorrock. BRE report BR 354.1998.

2. Carbon emission reductions from energy efficiency improvements to the UK housing stock. L D Shorrock, J Henderson, J I Utley and G A Walters. BRE report BR435.2001.

2 Introduction – domestic energy use in context

Energy use in the domestic sector accounts for a large proportion of total national energy consumption. This proportion has also increased from 25% to 30% of total consumption in the UK in the period from 1970 to 2001.

Energy usage is increasing in the domestic sector due to the increase in the number of households and the expectation of a higher level of service from electrical appliances, heating systems etc. However, increases in the fabric insulation of dwellings and higher efficiency of heating appliances have helped to control this increase.

Later sections of this report will discuss such trends in detail, presenting information which explains what has happened to domestic energy consumption, and the factors that affect this, over the last thirty years. Most of the information is for Great Britain (GB) but some tables also give United Kingdom (UK) values. All tables are clearly labelled as to the geographical area to which they apply.

Energy consumption 1970 to 2001

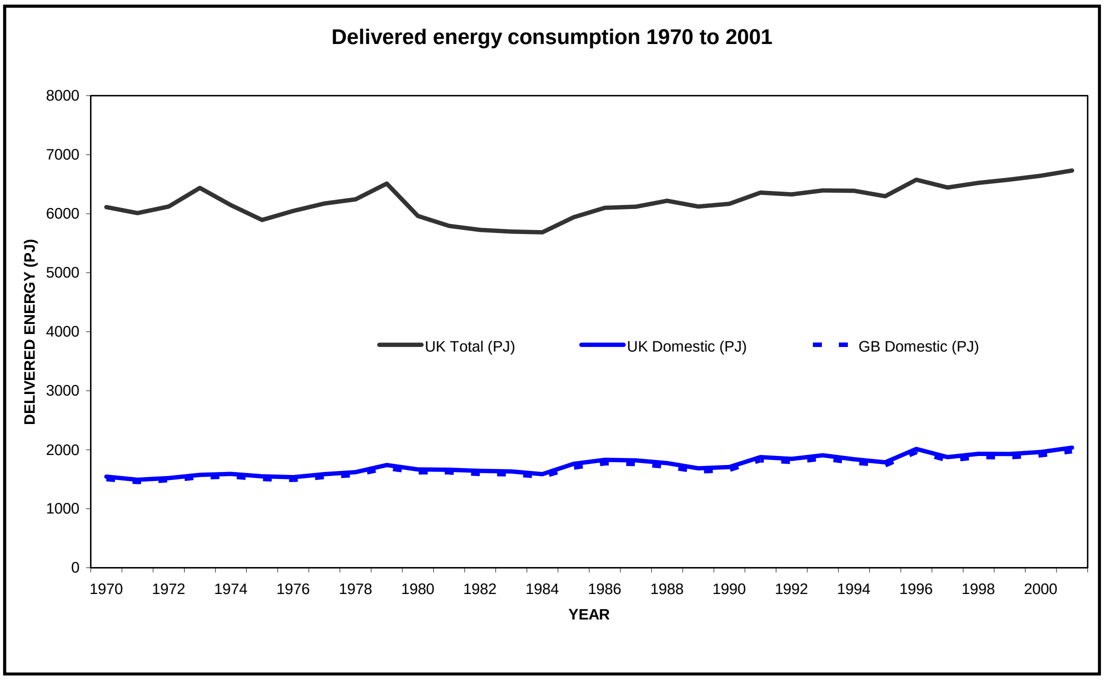


Figure 1. Delivered energy consumption 1970 - 2001

Figure 1 shows the total delivered energy consumption in the United Kingdom from 1970 to 2001.

It also shows the domestic sector energy consumption in Great Britain (GB) and the United Kingdom (UK), the difference between these being the energy use in Northern Ireland. Figures for GB have been estimated using UK and regional figures from the *Digest of United Kingdom Energy Statistics* [3] and the *Family Expenditure Survey* [4].

Domestic sector energy consumption is defined as energy used in dwellings. It excludes petrol use for family cars (which is classified separately under transport) and energy used in residential establishments such as hotels.

The figures for GB are more relevant to the rest of this report because most of the information that is presented later actually relates to GB rather than the UK.

Nonetheless, it is evident from Figure 1 that the difference between the energy use of the domestic sectors of GB and the UK is small (less than 3%) and fairly constant. Thus, GB figures can generally be assumed to apply to the UK when appropriately scaled up. Note, however, that there are some important differences between the energy use and energy efficiency characteristics of the housing stocks of GB and Northern Ireland. See the *Domestic Energy Fact File – England, Scotland, Wales and Northern Ireland* [5] for more details of these.

As the figures in Table 1 show, domestic sector energy use has risen more rapidly than overall energy use. In 1970 it represented 25% of total UK energy use. By 2001, this figure had increased to 30%. The size of this proportion, and the fact that it is growing, emphasises the importance of improving energy efficiency in the housing stock. Progress that has been made in this area is one of the main topics of this report.

Energy consumption 1970 to 2001

Table 1. Delivered energy consumption 1970-2001 (PJ) - GB and UK figures

Year	UK Total (PJ)	UK Domestic (PJ)	GB Domestic (PJ)
1970	6112	1544	1502
1971	6012	1491	1452
1972	6122	1518	1481
1973	6437	1573	1531
1974	6147	1591	1543
1975	5893	1552	1503
1976	6046	1534	1488
1977	6173	1587	1539
1978	6245	1620	1572
1979	6512	1740	1686
1980	5962	1668	1619
1981	5793	1661	1614
1982	5725	1642	1592
1983	5699	1634	1584
1984	5684	1587	1541
1985	5940	1761	1696
1986	6101	1830	1767
1987	6119	1820	1759
1988	6221	1774	1713
1989	6121	1685	1629
1990	6166	1706	1658
1991	6357	1874	1819
1992	6326	1845	1792
1993	6396	1907	1848
1994	6387	1840	1785
1995	6297	1787	1738
1996	6574	2014	1959
1997	6444	1874	1821
1998	6523	1931	1875
1999	6579	1929	1873
2000	6644	1960	1907
2001	6732	2034	1974

Source: Digest of United Kingdom Energy Statistics

3 Fuel prices, income and energy expenditure

Main trends

The amount of energy which households consume is determined largely by the level of service which they wish to achieve (for example, whole house heating or only partial house heating). This level of service determines the energy consumption through physical factors (the insulation standard of the dwelling, the efficiency of heating, appliances etc). The level of service which is chosen, in turn, depends in part on the cost of achieving that level. Clearly, this depends on the cost of the energy used and the disposable income of the household.

Fuel prices, income and energy expenditure are considered in this section and it is shown that, overall, fuel price variations have not had much direct effect on domestic energy use over the past thirty years or so. Rather, physical factors, as discussed in the following sections, offer the best explanation of the observed pattern of domestic energy use.

However, although this is true at an overall level, there can be no doubt that in many individual households this conclusion will not apply. For example, in a household which cannot afford to reach its desired level of service there will be a tendency to spend any extra disposable income in getting closer to that level – particularly where the existing level is very low.

Domestic fuel prices

The average domestic fuel price has not altered substantially in real terms over the period between 1970 and 1996. Although there have been occasional divergences, the domestic fuel price index has broadly kept pace with the retail price index over these years. It is interesting to note, however, that the real price of gas was falling at the time of both oil crises – most markedly at the time of the first oil crisis. This, undoubtedly, was a major factor in the rapid establishment of natural gas as the preferred fuel within the domestic sector (see section 9).

Since 1996 the retail price index has risen faster than the fuel price index and the cost of fuel has fallen in real terms. But average household expenditure on fuel, light and power has also decreased since 1996 implying that households have not been consuming more just because the prices are lower.

Average household expenditure

In real terms, the average household expenditure on fuel, light and power has remained relatively constant, although it has fallen in recent years as the price of energy has decreased.

Thus one concludes that the average energy consumption per household must have remained relatively constant. As shown in section 7, this conclusion is correct – the average energy consumption per household has actually declined very slightly.

Therefore, it would appear that, over the past thirty years, fuel prices have not played a major role in determining total domestic sector energy consumption. In real terms, households have not, in general, increased their expenditure on energy as their incomes have increased.

Individual household expenditure

However, despite the overall constancy of average expenditure, there are many households which are likely to be achieving a lower level of service than they would wish. Up to a certain income level, households invest a higher proportion of extra income on warmth than households earning above that level.

Retail price index and the index of fuel prices

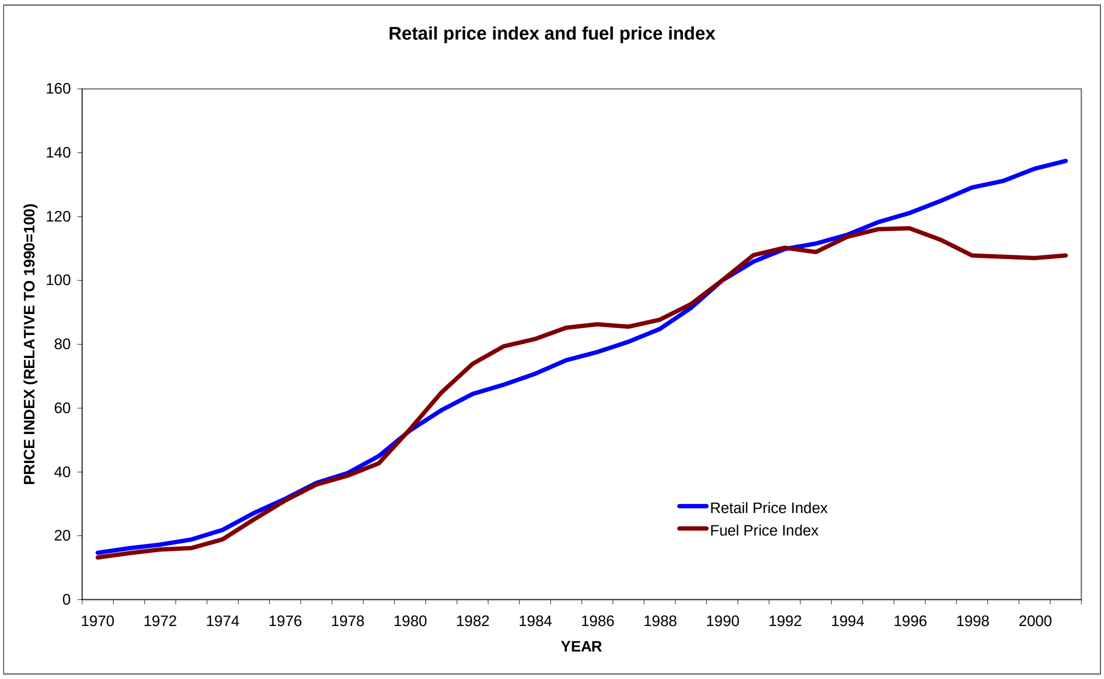


Figure 2. Retail price index and the index of fuel prices

Figure 2 illustrates the change in the index of fuel prices as against the index of retail prices. There have been times when fuel prices were rising more rapidly than retail prices but between 1970 and 1996 the two indices roughly kept pace with one another.

Since 1996, however, the fuel price index has not kept pace with the rise in the retail price index and the cost of fuel has fallen in real terms. Clearly, all other things being equal, falling fuel prices might be expected to result in households increasing their energy use. However, as the later parts of this report will show the energy use of the average household has actually not increased in this period. This indicates that there are other factors at work, including the continuing improvements to energy efficiency. These are presented in detail later in this report.

Retail price index and the index of fuel prices

Table 2. Retail price index and fuel price index - UK figures

		1990 = 100
Year	Retail Price Index	Fuel Price Index
1970	14.7	13.2
1971	16.1	14.6
1972	17.2	15.7
1973	18.8	16.1
1974	21.8	18.9
1975	27.1	25.1
1976	31.6	31.1
1977	36.6	36.1
1978	39.7	38.8
1979	45.0	42.7
1980	53.0	53.4
1981	59.3	64.8
1982	64.4	73.9
1983	67.3	79.4
1984	70.7	81.6
1985	75.0	85.2
1986	77.6	86.3
1987	80.8	85.5
1988	84.8	87.7
1989	91.4	92.6
1990	100.0	100.0
1991	105.9	107.9
1992	109.8	110.3
1993	111.6	108.9
1994	114.3	113.6
1995	118.2	116.0
1996	121.1	116.3
1997	124.9	112.7
1998	129.1	107.8
1999	131.2	107.4
2000	135.0	107.0
2001	137.4	107.8

Source: Digest of United Kingdom Energy Statistics

Domestic fuel prices

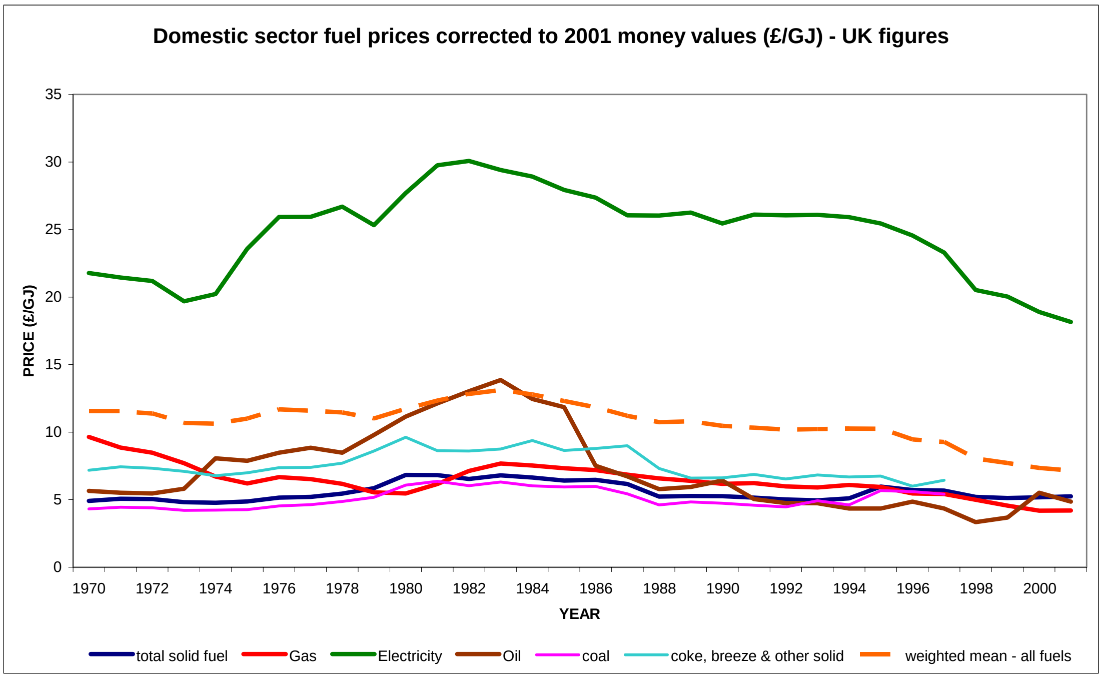


Figure 3. Domestic sector fuel prices corrected to 2001 money values (£/GJ)

Figure 3 shows the average domestic fuel prices corrected to 2001 money values by using the retail price index shown in Table 2. These prices encompass all relevant tariffs and are inclusive of any standing charges and Value Added Tax when appropriate.

The weighted mean shows relatively little variation between 1970 and the mid-90s but then falls significantly thereafter, confirming the pattern seen in the fuel price index.

Individual prices have varied more than the general trend. Oil prices rose sharply in the early and late 70s and early 80s but then fell sharply in 1986. Electricity prices followed a similar trend but levelled out more in the early 90s before continuing the downward trend. Gas prices, too, rose in the early 80s although not so dramatically and have gradually fallen since.

Separate values are available for coal and other solid fuel for the years up to and including 1997. Domestic consumption of solid fuel has decreased to the point where it is no longer possible to provide disaggregated values on current sample sizes. The weighted mean shows a slight decrease in prices since 1983.

Domestic fuel prices

Table 3. Domestic sector fuel prices corrected to 2001 money values (£/GJ) - UK figures

Year	Coal	Coke, breeze + other solid	total solid fuel	Gas	Electricity	Oil	weighted mean - all fuels
1970	4.32	7.18	4.91	9.65	21.79	5.65	11.55
1971	4.44	7.43	5.08	8.85	21.45	5.51	11.56
1972	4.41	7.33	5.05	8.48	21.19	5.47	11.39
1973	4.21	7.09	4.82	7.70	19.69	5.82	10.69
1974	4.23	6.78	4.78	6.71	20.22	8.06	10.63
1975	4.26	6.99	4.87	6.20	23.58	7.87	11.00
1976	4.53	7.36	5.15	6.66	25.93	8.48	11.69
1977	4.63	7.40	5.21	6.52	25.95	8.85	11.58
1978	4.87	7.70	5.45	6.18	26.70	8.48	11.45
1979	5.17	8.60	5.85	5.55	25.32	9.80	11.00
1980	6.08	9.62	6.83	5.46	27.70	11.15	11.72
1981	6.37	8.63	6.82	6.16	29.76	12.13	12.33
1982	6.04	8.60	6.54	7.12	30.08	13.03	12.83
1983	6.31	8.75	6.80	7.68	29.40	13.87	13.11
1984	6.03	9.38	6.64	7.54	28.91	12.45	12.79
1985	5.95	8.64	6.42	7.33	27.92	11.85	12.31
1986	5.98	8.79	6.47	7.19	27.37	7.51	11.83
1987	5.44	8.99	6.16	6.86	26.04	6.73	11.21
1988	4.61	7.31	5.23	6.57	26.03	5.79	10.74
1989	4.83	6.60	5.27	6.40	26.26	5.95	10.80
1990	4.74	6.62	5.26	6.18	25.45	6.42	10.47
1991	4.59	6.87	5.16	6.23	26.11	5.05	10.34
1992	4.47	6.54	5.02	5.98	26.05	4.76	10.19
1993	4.93	6.83	4.96	5.91	26.09	4.73	10.23
1994	4.61	6.69	5.10	6.10	25.91	4.35	10.27
1995	5.68	6.75	5.97	5.95	25.45	4.35	10.25
1996	5.59	6.00	5.72	5.46	24.56	4.85	9.46
1997	5.41	6.44	5.67	5.42	23.30	4.34	9.28
1998	-	-	5.21	5.00	20.52	3.34	8.05
1999	-	-	5.13	4.56	20.04	3.68	7.72
2000	-	-	5.18	4.19	18.89	5.52	7.35
2001	-	-	5.24	4.20	18.16	4.86	7.15

Source: Digest of United Kingdom Energy Statistics

Household expenditure on fuel, light and power

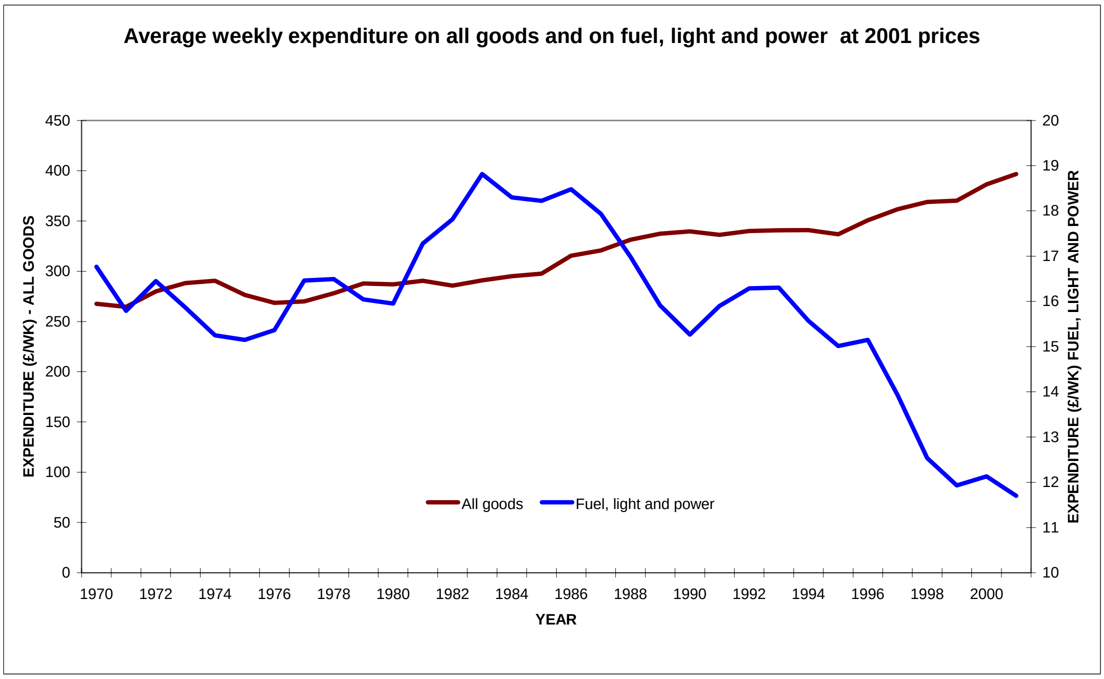


Figure 4. Average weekly expenditure on all goods, and on fuel, light and power at 2001 prices

Figure 4 shows the average weekly expenditure on all goods and that on fuel, light and power corrected to 2001 values. Expenditure on all goods shows a steady increase from 1970 to 2001. Expenditure on fuel, light and power is more volatile but, following a steep rise between 1980 and 1983, it fell back to its previous level before decreasing quite dramatically after 1996 as fuel prices fell.

As Table 4 shows, the proportion of expenditure spent on fuel, light and power has decreased by a factor of more than two - from 6.3% in 1970 to 2.9% in 2001.

Household expenditure on fuel, light and power

Table 4. Average weekly expenditure on all goods, and on fuel, light and power (£/week) - UK figures

	Contemporary prices		2001 prices		
Year	All goods (£/week)	Fuel light & power (£/week)	All goods (£/week)	Fuel light & power (£/week)	% on Fuel light & power
1970	28.57	1.79	267.57	16.76	6.3%
1971	30.99	1.85	264.50	15.79	6.0%
1972	35.06	2.06	279.93	16.45	5.9%
1973	39.43	2.17	288.26	15.86	5.5%
1974	46.13	2.42	290.64	15.25	5.2%
1975	54.58	2.99	276.51	15.15	5.5%
1976	61.70	3.53	268.60	15.37	5.7%
1977	71.84	4.38	270.00	16.46	6.1%
1978	80.26	4.76	278.12	16.49	5.9%
1979	94.17	5.25	287.76	16.04	5.6%
1980	110.60	6.15	286.87	15.95	5.6%
1981	125.41	7.46	290.49	17.28	5.9%
1982	133.92	8.35	285.75	17.82	6.2%
1983	142.59	9.22	290.99	18.82	6.5%
1984	151.92	9.42	295.09	18.30	6.2%
1985	162.50	9.95	297.62	18.22	6.1%
1986	178.10	10.43	315.52	18.48	5.9%
1987	188.62	10.55	320.71	17.94	5.6%
1988	204.41	10.48	331.30	16.99	5.1%
1989	224.32	10.58	337.38	15.91	4.7%
1990	247.16	11.11	339.60	15.27	4.5%
1991	259.04	12.25	336.19	15.90	4.7%
1992	271.83	13.02	340.06	16.29	4.8%
1993	276.68	13.24	340.71	16.30	4.8%
1994	283.58	12.95	340.97	15.57	4.6%
1995	289.86	12.92	336.83	15.01	4.5%
1996	309.07	13.35	350.69	15.15	4.3%
1997	328.78	12.66	361.68	13.93	3.9%
1998	346.58	11.78	368.86	12.54	3.4%
1999	353.47	11.39	370.17	11.93	3.2%
2000	379.61	11.92	386.36	12.13	3.1%
2001	396.80	11.70	396.80	11.70	2.9%

Source: Family Expenditure Survey
Expenditure and Food Survey

In years where the survey relates to financial years it has been assumed to apply to the calendar year at the start of the financial year.

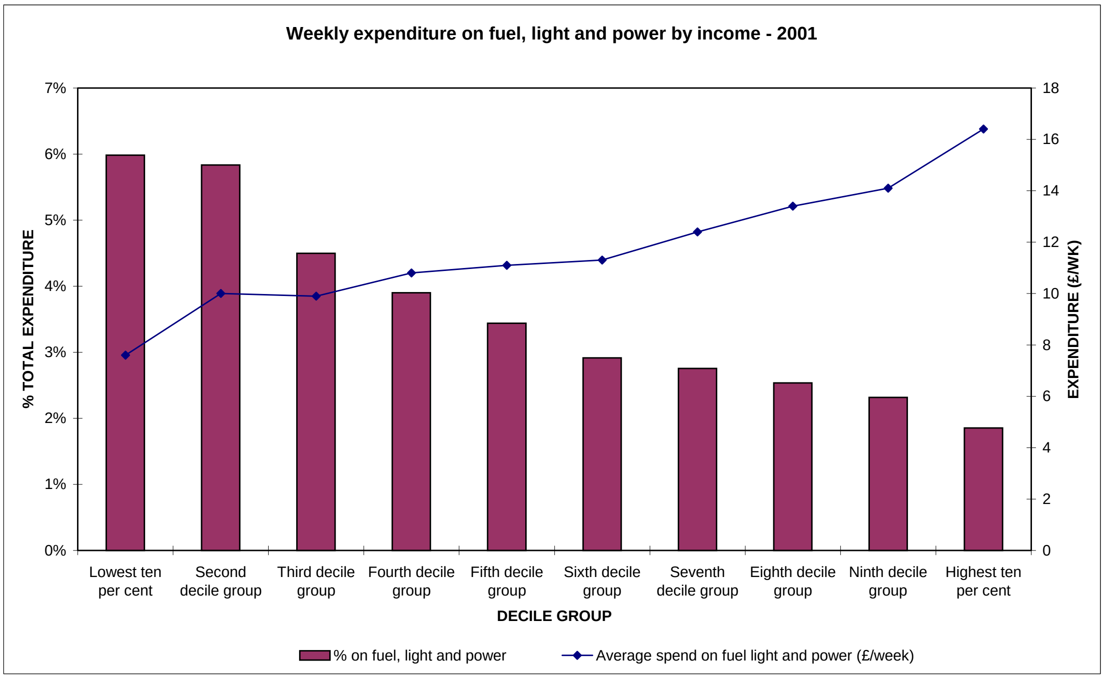


Figure 5. Weekly expenditure and percentage expenditure on fuel, light and power by income – 2001.

Figure 5 shows the average weekly expenditure on fuel, light and power related to income for 2001. The percentage of weekly expenditure spent on fuel, light and power increases as income falls.

In 1996 households in the lowest ten per cent income group were spending 9.9% of weekly expenditure on fuel, light and power; by 2001 this had fallen to 6.0%. Households in the top ten per cent income group were spending 2.8% in 1996 and 1.9% in 2001. These figures are indicative of a reduction in the problems of fuel poverty in recent years, at least a part of which can be attributed to the energy efficiency improvements discussed later in this report, although reducing fuel prices have obviously been important as well. Details of the government's fuel poverty strategy can be found on the DTI web site at www.dti.gov.uk/energy/consumers/fuel_poverty/strategy/shtml.

Household income and weekly expenditure

Table 5. Weekly expenditure on fuel, light and power by income (£/week) - UK figures 2001

Gross income decile group	Lower boundary of income (£/week)	Average spend on fuel light and power (£/week)	Average total spend (£/week)	% on fuel, light and power
Lowest ten per cent		7.6	127	6.0%
Second decile group	115	10	171.4	5.8%
Third decile group	175	9.9	220.2	4.5%
Fourth decile group	246	10.8	276.9	3.9%
Fifth decile group	327	11.1	322.6	3.4%
Sixth decile group	425	11.3	387.6	2.9%
Seventh decile group	527	12.4	450.2	2.8%
Eighth decile group	648	13.4	528.7	2.5%
Ninth decile group	809	14.1	608.6	2.3%
Highest ten per cent	1085	16.4	884.7	1.9%

Source: Expenditure and Food Survey

4 Population, households and the housing stock

Main trends

National domestic energy use is affected by the size of the population and the number of households, and by the composition of the housing stock in terms of age, building type, tenure and regional distribution.

Number and size of households

The number of households has increased, while the number of occupants per household has decreased. The trend to smaller households would result, all other things being equal, in a higher consumption per capita.

Age of stock

The growth of the housing stock has been subject to increasingly strict Building Regulation thermal requirements. Demolition tends to be of older, less well insulated dwellings. This tends to improve the efficiency over time.

Effect of tenure

Owner occupation has become an increasingly common form of tenure, making more occupiers directly responsible for the thermal performance of dwellings.

Dwelling types

There has been a small growth in the proportion of detached dwellings, tending to increase the average heat loss per dwelling. Equally, however, the proportion of flats has increased which tends to reduce the average heat loss per dwelling.

Geographical location

Climatic variations have a large effect on heating requirements. Regional distribution of the housing stock is biased towards the warmer south east of Britain; the trend is slightly to increase that bias.

Population and the number of households

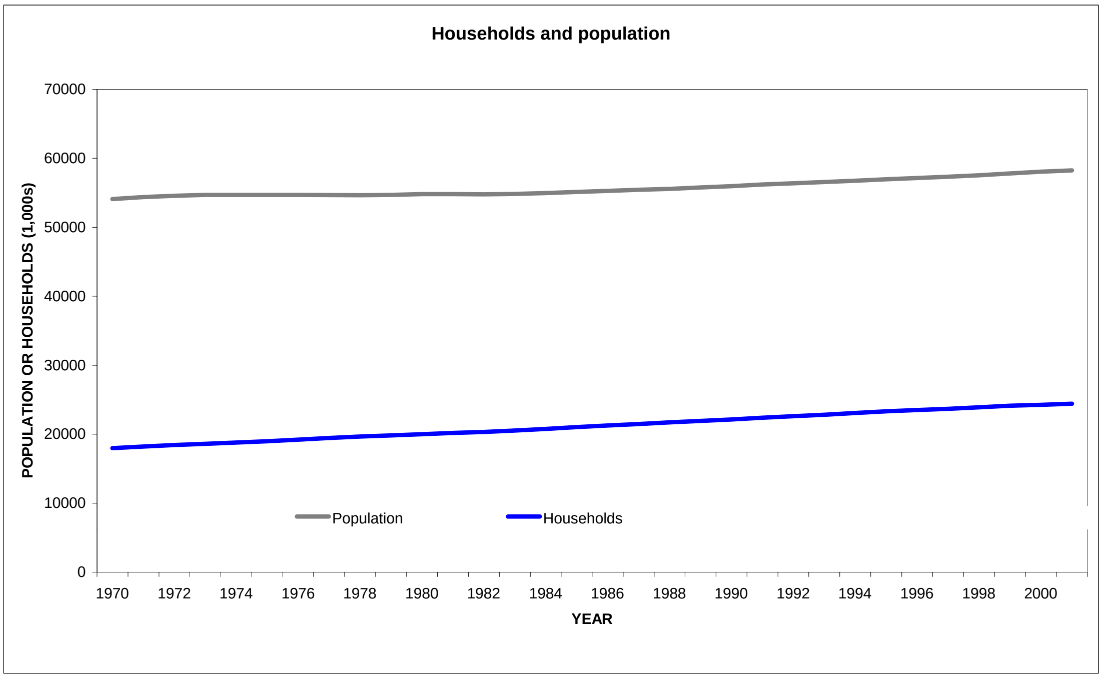


Figure 6. Households and population

Figure 6 shows the total population and the number of households in Great Britain. Since 1970 the population has increased by 4.1 million while the number of households has increased by 6.4 million implying that the mean household size has decreased. Table 6 shows that the mean household size has decreased from 2.9 in 1971 to 2.3 in 2000.

The decrease in household size is due to a trend towards smaller families and a larger number of single people living alone. Energy consumption relates to the number of people in the household but there is a minimum level of consumption related to the running of the house which is independent of household size. The trend towards smaller households will lead to a higher per capita energy consumption, all other things being equal.

Table 6 shows both the mean household size taken from the General Household Survey [6] and the household size defined as population divided by households. Mean household size is a more appropriate measure for assessing energy consumption as it excludes residents of institutions, members of the armed forces and others not living in dwellings.

Population and the number of households

Table 6. Population, households and household size - GB figures

Year	Population (1,000s)	Households (1,000s)	Popul./ H'holds	Mean Size GHS
1970	54105	17987	3.01	
1971	54388	18221	2.98	2.91
1972	54558	18426	2.96	
1973	54693	18603	2.94	2.83
1974	54709	18783	2.91	
1975	54702	18988	2.88	2.78
1976	54693	19215	2.85	
1977	54667	19450	2.81	2.71
1978	54655	19650	2.78	
1979	54712	19827	2.76	2.67
1980	54797	20010	2.74	
1981	54815	20177	2.72	2.70
1982	54780	20327	2.69	
1983	54834	20525	2.67	2.64
1984	54955	20769	2.65	2.59
1985	55127	21017	2.62	2.56
1986	55285	21254	2.60	2.55
1987	55434	21485	2.58	2.55
1988	55580	21710	2.56	2.48
1989	55775	21927	2.54	2.51
1990	55972	22140	2.53	2.46
1991	56207	22392	2.51	2.48
1992	56388	22595	2.50	2.45
1993	56559	22822	2.48	2.44
1994	56753	23076	2.46	2.44
1995	56957	23315	2.44	2.40
1996	57138	23492	2.43	-
1997	57334	23694	2.42	-
1998	57548	23896	2.41	2.32
1999	57809	24120	2.40	-
2000	58058	24271	2.39	2.30
2001	58246	24422	2.38	-

Sources: Population – Annual Abstract of Statistics
Households – Housing and Construction Statistics
Mean household size – General Household Survey

Age of the housing stock

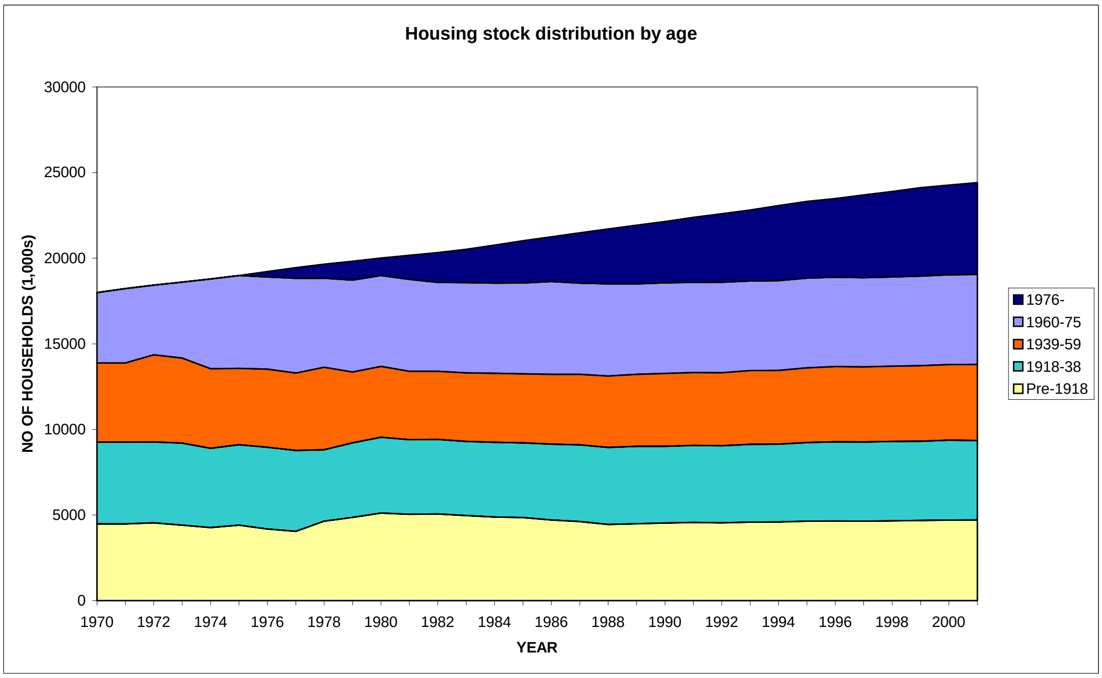


Figure 7. Housing stock distribution by age

There are a number of age related factors which influence the energy consumption of a building. The increase in numbers of dwellings comes from new buildings and conversion of older buildings into more than one dwelling. At the same time dwellings are being demolished. This is generally the older properties which were built to lower thermal standards.

New dwellings are built to more stringent Building Regulations which control the thermal characteristics of the dwelling. Changes were made in 1965, 1976, 1982 and 1990. These changed the U-values for roofs to 1.42, 0.6, 0.35 and 0.25 $W/m^2 \, ^oC$ for the four years respectively and for walls to 1.7, 1.0, 0.6, 0.45 $W/m^2 \, ^oC$. The 1990 changes also introduced a U-value requirement of 0.45 $W/m^2 \, ^oC$ for ground floors.

The 1994 revision of the Building Regulations introduced new values for some building elements in dwellings where the SAP energy rating will be less than or equal to 60. These were roofs 0.2$W/m^2 \, ^oC$, exposed floors and ground floors 0.35 $W/m^2 \, ^oC$ and windows, doors and roof lights 3.0 $W/m^2 \, ^oC$.

The most recent changes came into effect in 2002 (i.e. beyond the end of the period covered by this report) and will mean that the majority of dwellings will be built with filled cavity walls (or equivalent) and double glazing in future, meeting U-values of 0.35 $W/m^2 \, ^oC$ for walls, 0.25 $W/m^2 \, ^oC$ for floors, 0.16$W/m^2 \, ^oC$ for roofs, and 2.0$W/m^2 \, ^oC$ or 2.2$W/m^2 \, ^oC$ for windows depending on the frame.

The Building Regulations referred to above are those for England and Wales. Separate requirements apply in Scotland but these are generally equivalent to those in England and Wales, differing only slightly in the timing of their introduction.

Age of the housing stock

Table 7. Housing stock distribution by age (1,000s) - GB figures

Year	Pre-1918	1918-38	1939-59	1960-75	1976-	Total
1970	4474	4779	4625	4109	0	17987
1971	4474	4779	4625	4343	0	18221
1972	4544	4725	5094	4063	0	18426
1973	4404	4800	4965	4435	0	18603
1974	4271	4623	4645	5245	0	18784
1975	4403	4707	4452	5426	0	18988
1976	4187	4773	4563	5375	316	19215
1977	4040	4723	4522	5542	624	19451
1978	4639	4170	4816	5208	818	19651
1979	4863	4350	4143	5367	1105	19827
1980	5111	4432	4140	5304	1023	20010
1981	5041	4359	3993	5366	1417	20176
1982	5061	4356	3984	5180	1746	20327
1983	4964	4332	4003	5274	1952	20525
1984	4882	4364	4028	5263	2230	20768
1985	4851	4363	4033	5306	2464	21017
1986	4718	4422	4082	5418	2613	21252
1987	4622	4470	4121	5329	2944	21486
1988	4452	4493	4170	5385	3211	21711
1989	4493	4514	4211	5286	3423	21928
1990	4536	4473	4260	5290	3581	22140
1991	4568	4501	4254	5262	3806	22391
1992	4542	4497	4271	5287	3998	22595
1993	4585	4543	4315	5226	4153	22821
1994	4592	4546	4315	5241	4383	23076
1995	4640	4596	4363	5246	4472	23316
1996	4649	4627	4396	5217	4604	23492
1997	4642	4620	4384	5214	4834	23694
1998	4659	4636	4397	5210	4994	23896
1999	4678	4631	4415	5235	5161	24120
2000	4707	4662	4419	5245	5239	24272
2001	4712	4640	4448	5252	5370	24421

Source: GfK Home Audit

Housing stock distribution by tenure

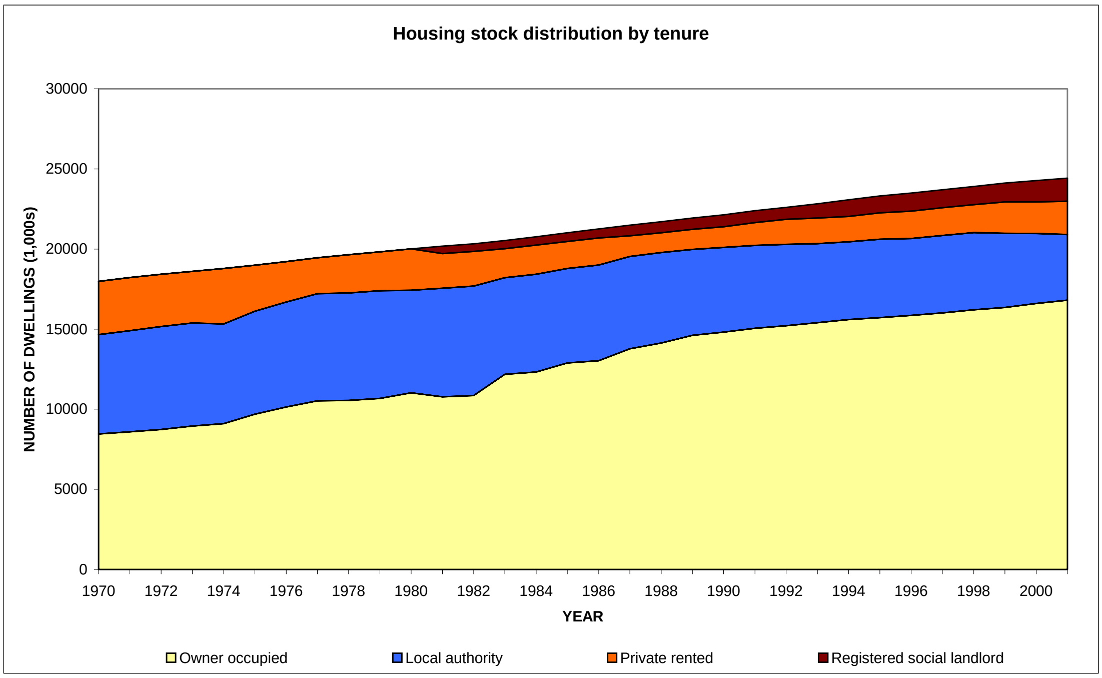


Figure 8. Housing stock distribution by tenure

Figure 8 shows the distribution of housing stock by tenure. The proportion of owner occupied dwellings has increased from 47% in 1970 to 68.8% in 2001.

During this period the percentage of privately rented properties has dropped from 18.5% to 8.5%. Local authority properties have also decreased from 34.5% to 16.8% of the stock due to Right to Buy and Stock Transfer policies.

Registered social landlords who are mainly housing associations now account for 5.9% of the stock.

Owner occupiers are more likely to invest in energy saving measures than those in rented accommodation, and particularly those in private rented accommodation. In 2001, for example, 93% of owner occupied homes with lofts had loft insulation and 83% of owner occupied homes had double glazing. The corresponding figures for the private rented sector were just 68% with loft insulation and 46% with double glazing. Thus, the move towards greater numbers of owner occupied homes should have had a positive effect on improving energy efficiency.

Housing stock distribution by tenure

Table 8. Housing stock distribution by tenure (1,000s) - GB figures

Year	Owner occupied	Local authority	Private rented	Registered social landlord	Total
1970	8454	6206	3328	0	17987
1971	8591	6314	3315	0	18221
1972	8742	6423	3261	0	18426
1973	8948	6429	3227	0	18603
1974	9094	6223	3466	0	18783
1975	9685	6430	2872	0	18988
1976	10138	6552	2525	0	19215
1977	10529	6685	2236	0	19450
1978	10550	6703	2397	0	19650
1979	10672	6718	2437	0	19827
1980	11023	6402	2585	0	20010
1981	10778	6777	2153	469	20177
1982	10857	6828	2159	483	20327
1983	12175	6030	1816	504	20525
1984	12319	6102	1823	525	20769
1985	12884	5903	1682	548	21017
1986	13029	5972	1687	565	21254
1987	13777	5751	1290	666	21485
1988	14133	5645	1238	694	21710
1989	14607	5369	1250	701	21927
1990	14813	5289	1284	753	22140
1991	15048	5173	1433	739	22392
1992	15207	5084	1558	746	22595
1993	15405	4930	1597	890	22822
1994	15599	4845	1593	1039	23076
1995	15713	4897	1655	1050	23315
1996	15858	4790	1715	1128	23492
1997	16017	4833	1729	1115	23694
1998	16201	4827	1743	1124	23896
1999	16353	4630	1955	1182	24120
2000	16601	4368	1966	1337	24271
2001	16800	4103	2077	1442	24422

Source: GfK Home Audit

Note that prior to 1981 RSL homes are included within the figures for private rented.

House types

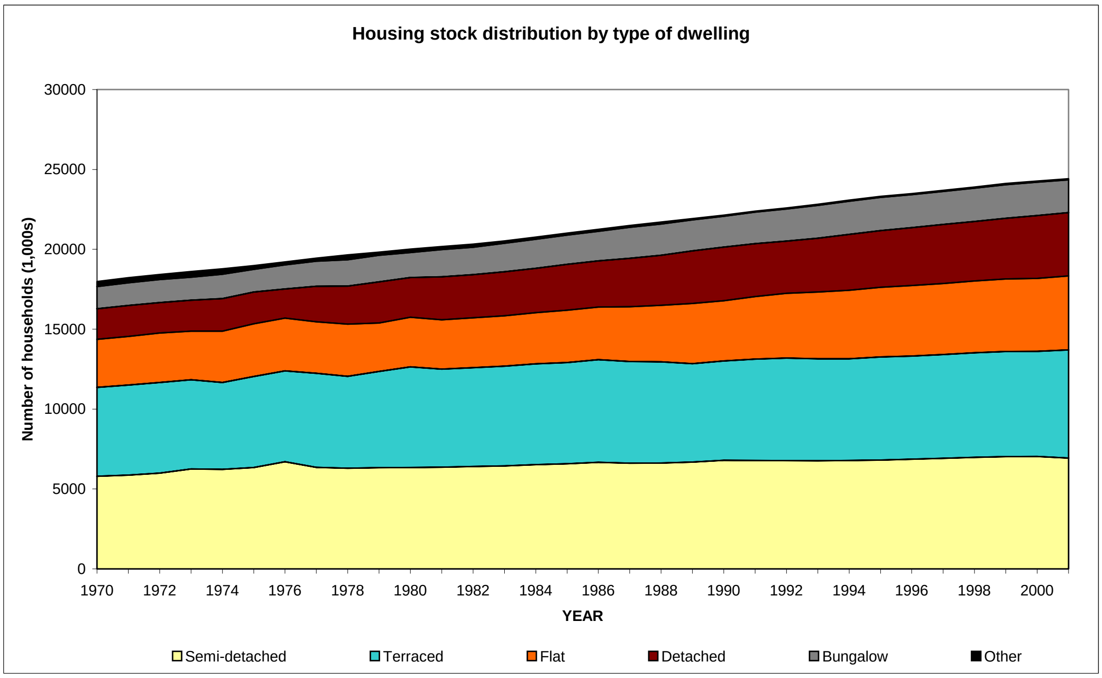


Figure 9. Housing stock distribution by type of dwelling

The proportion of different dwelling types has only changed slightly since 1970. The biggest increase is in detached houses which have increased by 5.6%. There has also been a 2.3% increase in flats. Terraced and semi detached houses have decreased by 3.2% and 3.8%.

A detached house will have a greater surface to volume ratio and hence greater heat loss than any other dwelling built to the same standard using the same materials. Detached houses are also likely to have a greater floor area than other types of dwelling. Flats have a smaller surface to volume ratio and hence a lower heat loss. They are also likely to have a smaller floor area.

Such considerations mean that the characteristic heat losses of different dwelling types are appreciably different. For example, typical average heat losses of existing dwellings would be as follows:

Detached	365 W/°C
Semi detached	276 W/°C
Terraced	243 W/°C
Bungalow	229 W/°C
Flat	182 W/°C

The overall average heat loss for all dwellings currently in the housing stock would be about 259 W/°C (see Table 19).

The increase in the proportion of detached houses will tend to increase the average heat loss of the stock while the increase in the proportion of flats will tend to decrease it.

House types

Table 9. Housing stock distribution by type (1,000s) - GB figures

Year	Semi-detached	Terraced	Flat	Detached	Bungalow	Other	Total
1970	5794	5566	3003	1915	1392	317	17987
1971	5869	5638	3043	1940	1410	321	18221
1972	5992	5667	3100	1905	1439	322	18426
1973	6254	5583	3036	1945	1443	342	18603
1974	6224	5442	3209	2039	1525	344	18783
1975	6341	5701	3298	1986	1422	239	18988
1976	6707	5680	3301	1834	1505	187	19215
1977	6359	5879	3226	2231	1564	191	19450
1978	6293	5752	3277	2377	1643	309	19650
1979	6332	6023	3027	2581	1663	201	19827
1980	6347	6293	3104	2491	1569	207	20010
1981	6362	6139	3092	2687	1697	201	20177
1982	6412	6185	3115	2705	1708	203	20327
1983	6441	6239	3160	2755	1785	144	20525
1984	6519	6315	3200	2783	1806	147	20769
1985	6583	6334	3275	2871	1829	126	21017
1986	6674	6419	3295	2891	1849	126	21254
1987	6618	6361	3432	3030	1936	108	21485
1988	6621	6340	3537	3128	1952	130	21710
1989	6687	6159	3768	3293	1932	88	21927
1990	6796	6218	3766	3365	1929	67	22140
1991	6785	6338	3919	3314	1970	67	22392
1992	6779	6418	4044	3276	2011	68	22595
1993	6757	6390	4176	3376	2054	68	22822
1994	6784	6368	4290	3487	2078	69	23076
1995	6807	6458	4359	3546	2075	69	23315
1996	6860	6459	4416	3619	2068	71	23492
1997	6917	6494	4454	3696	2061	72	23694
1998	6976	6547	4492	3731	2079	72	23896
1999	7019	6584	4535	3811	2098	73	24120
2000	7037	6578	4562	3933	2088	74	24271
2001	6936	6766	4639	3956	2051	73	24422

Source: GfK Home Audit

Regional distribution of the housing stock

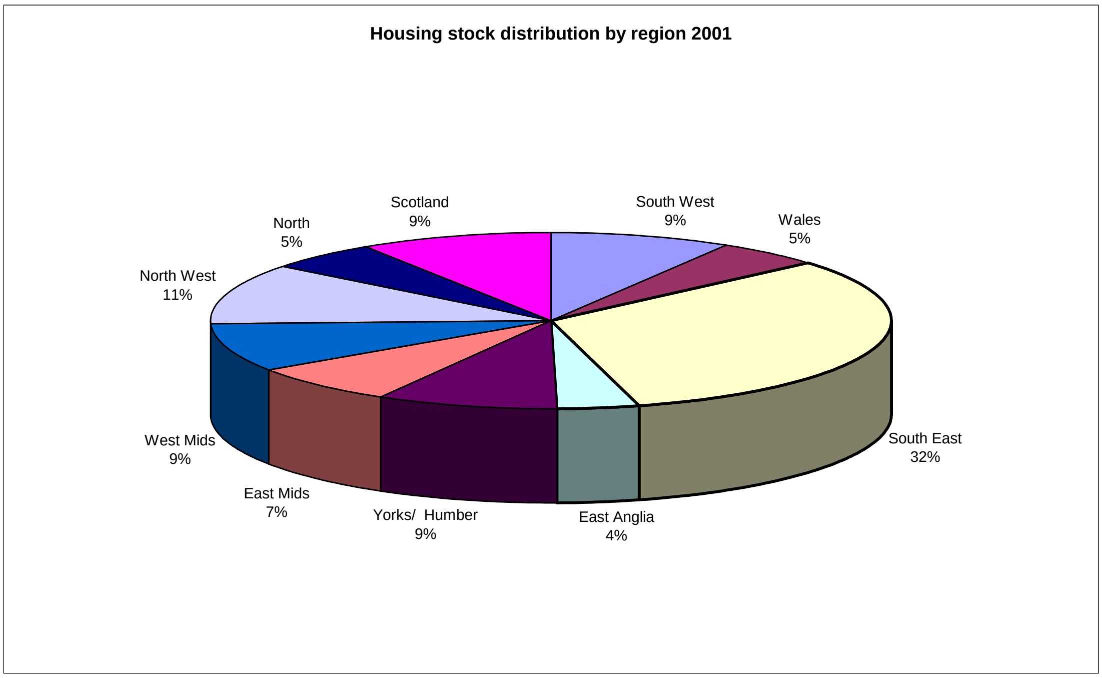


Figure 10. Housing stock distribution by region

Energy consumption will differ for identical houses in different regions because of climatic differences. A house in Scotland, in an average year, will require nearly 45% more energy to maintain a given temperature than the same house in the South West.

Figure 10 shows that in 2001 nearly a third of households were in the South East. The percentages in each region change very little with time.

Regional distribution of the housing stock

Table 10. Housing stock distribution by region (1,000s) - GB figures

Year	South West	Wales	South East	East Anglia	Yorks/ Humber	East Mids	West Mids	North West	North	Scotland	Total GB
1970	1390	876	5889	504	1708	1057	1654	2213	1053	1643	17987
1971	1408	887	5966	511	1730	1071	1675	2242	1067	1665	18221
1972	1424	897	6033	516	1750	1083	1694	2267	1079	1683	18426
1973	1437	906	6091	521	1766	1093	1710	2289	1089	1699	18603
1974	1451	915	6150	527	1784	1104	1727	2311	1100	1716	18783
1975	1540	918	6286	576	1776	1168	1661	2318	991	1753	18988
1976	1396	988	6230	634	1758	1223	1795	2359	1112	1719	19215
1977	1537	962	6177	648	1761	1348	1824	2321	1096	1777	19450
1978	1513	993	6141	716	1773	1546	1727	2303	1120	1817	19650
1979	1679	1041	6040	753	1750	1346	1919	2339	1174	1786	19827
1980	1633	1010	6236	688	1841	1411	1887	2353	1154	1797	20010
1981	1648	1001	6426	710	1816	1403	1869	2371	1115	1818	20177
1982	1661	1008	6474	716	1828	1414	1884	2389	1123	1831	20327
1983	1660	1037	6481	712	1851	1433	1895	2412	1176	1868	20525
1984	1680	1049	6559	720	1873	1450	1917	2440	1190	1890	20769
1985	1726	1051	6729	742	1877	1469	1952	2409	1162	1900	21017
1986	1746	1063	6805	751	1897	1486	1974	2436	1175	1921	21254
1987	1772	1083	6740	774	1942	1519	1992	2496	1220	1946	21485
1988	1808	1053	6867	793	1975	1546	2013	2472	1220	1963	21710
1989	1845	1054	6940	805	1991	1561	2030	2483	1223	1995	21927
1990	1880	1069	7014	817	2006	1576	2044	2491	1229	2015	22140
1991	1905	1080	7125	840	2015	1610	2060	2501	1222	2033	22392
1992	1928	1089	7197	849	2020	1631	2076	2524	1229	2052	22595
1993	1938	1159	7207	847	2015	1625	2081	2572	1271	2107	22822
1994	1975	1171	7317	869	2014	1646	2109	2509	1304	2162	23076
1995	1987	1175	7375	875	2056	1672	2121	2613	1289	2152	23315
1996	2001	1180	7435	876	2089	1682	2137	2634	1299	2159	23492
1997	2035	1187	7528	895	2097	1703	2144	2635	1301	2168	23693
1998	2045	1195	7608	896	2115	1716	2170	2664	1312	2175	23895
1999	2075	1206	7694	916	2122	1737	2171	2678	1327	2195	24121
2000	2112	1190	7791	947	2136	1748	2161	2670	1311	2208	24272
2001	2125	1196	7840	952	2149	1758	2173	2686	1318	2223	24421

Source: GfK Home Audit

5 Fabric insulation

Main Trends

Figures on the acquisition and ownership of insulation have been gathered since 1974 by the market research organisation GfK Marketing Services Ltd (formerly G & A Marketing Services Ltd) as part of the GfK Home Audit. Figures from this source have been adjusted pro-rata to those used elsewhere in this report for total number of households.

Take up of insulation

The measures covered have been loft insulation, cavity insulation, double glazing, draught proofing and hot water tank lagging (the last of these being discussed in section 6).

There has been an increase in the proportion of houses in which insulation measures have been installed and a saturation level appears to have been reached for the two most obviously cost-effective – hot water tank lagging and loft insulation. These are also the two measures for which grants were made available under the Homes Insulation Scheme. This scheme ran from 1978 to 1990 and has now been superseded by new schemes aimed particularly at those on low incomes. These schemes are also now covering other important energy efficiency measures such as cavity wall insulation.

Ownership of cavity wall insulation, a measure which can save more energy than loft and tank insulation, but which has a longer payback period for its capital cost, has now reached about a third of its potential.

Potential for take-up

The tables covering insulation measures include a column labelled ‘potential’. For loft insulation the ‘potential’ is the number of houses with accessible lofts. For cavity insulation the ‘potential’ is the number of houses with cavity walls – although it must be recognised that a proportion of these could not actually have the cavity filled because their location is such that there would then be a risk of rain penetration. For other measures that are not limited to any particular category of house the potential is equivalent to the whole of the housing stock.

Influences on take-up

There is evidence of higher proportions of insulated dwellings where the householder is in a better position to pay for the insulation or where consumption levels are high so that the incentive to save is greater. There is proportionally more insulation in owner occupied dwellings, dwellings owned by higher income groups and dwellings with central heating.

Loft insulation

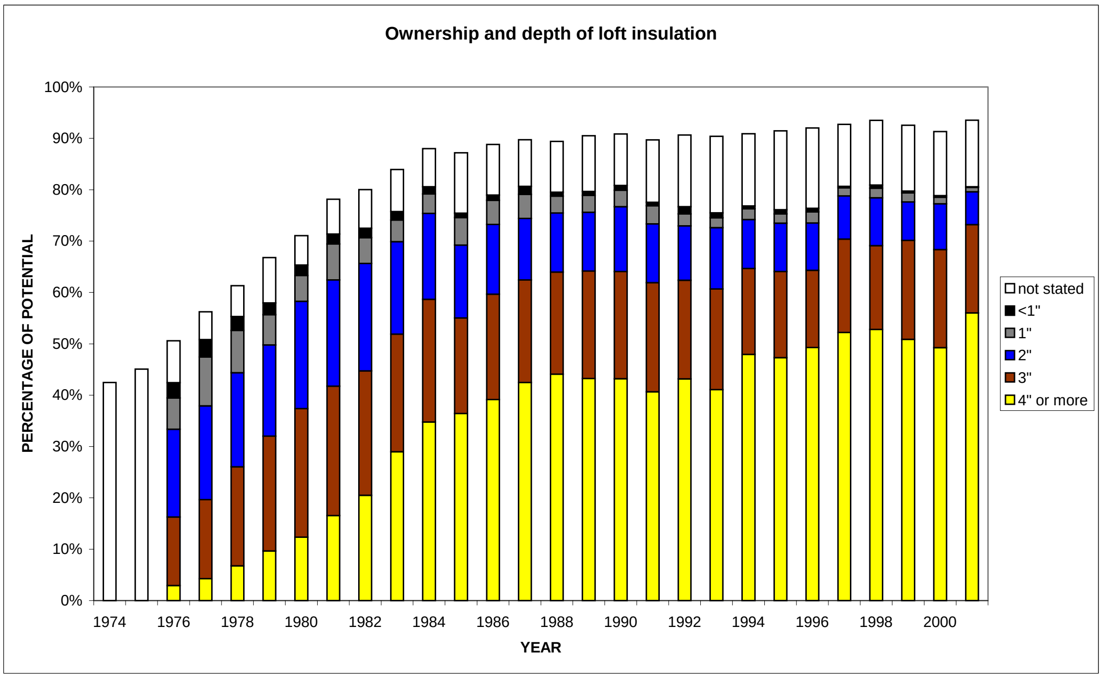


Figure 11. Ownership and depth of loft insulation

In 1974 there was some loft insulation in 42.5% of accessible lofts. This had increased to 93.5% by 2001.

Depths of loft insulation have been increasing and the percentage of those with depths over 4 inches has also been increasing. In 1991, 40.7% had 4 inches or more of insulation, of those, 41.9% had 5 inches or more. By 2001 56% had 4 inches or more of insulation, 53.2% of which had 5 inches or more of insulation and 32.8% of which had at least 6 inches.

Loft insulation

Table 11. Ownership and depth of loft insulation (1,000s) - GB figures

Year	<1"	1"	2"	3"	4"	4"+	5"	5"+	6"+	Not stated	Total with	Potential	Total houses
1974	-	-	-	-	-	-	-	-	-	5945	5945	14005	18783
1975	-	-	-	-	-	-	-	-	-	6384	6384	14158	18988
1976	424	877	2447	1909	-	422	-	-	-	1166	7246	14327	19215
1977	495	1396	2668	2253	-	624	-	-	-	790	8226	14627	19450
1978	398	1203	2682	2814	-	993	-	-	-	874	8965	14626	19650
1979	348	900	2711	3411	-	1475	-	-	-	1346	10192	15265	19827
1980	321	789	3291	3943	-	1944	-	-	-	902	11189	15748	20010
1981	308	1106	3282	3996	-	2627	-	-	-	1074	12392	15860	20177
1982	297	811	3387	3921	-	3321	-	-	-	1219	12957	16189	20327
1983	274	691	2964	3772	-	4774	-	-	-	1347	13821	16469	20525
1984	235	638	2826	4034	-	5869	-	-	-	1254	14857	16884	20769
1985	143	921	2427	3187	-	6244	-	-	-	2019	14941	17133	21017
1986	180	820	2379	3588	-	6853	-	-	-	1723	15543	17503	21254
1987	271	824	2101	3502	5035	-	-	2408	-	1588	15728	17530	21485
1988	137	588	2050	3544	5085	-	-	2769	-	1762	15934	17821	21710
1989	142	575	2016	3684	4960	-	-	2659	-	1908	15943	17614	21927
1990	168	583	2281	3764	4935	-	-	2865	-	1807	16403	18054	22140
1991	122	634	2055	3823	4251	-	-	3064	-	2183	16133	17986	22392
1992	256	422	1908	3456	4890	-	-	2890	-	2515	16335	18018	22595
1993	178	356	2200	3607	4618	-	-	2955	-	2742	16657	18426	22822
1994	98	382	1729	3039	4657	-	1455	-	2585	2550	16494	18147	23076
1995	150	330	1724	3078	4235	-	1490	-	2945	2814	16765	18334	23315
1996	132	401	1717	2794	4466	-	1398	-	3310	2911	17129	18613	23492
1997	50	302	1588	3426	4661	-	1548	-	3643	2281	17497	18866	23694
1998	112	352	1759	3078	4739	-	1901	-	3318	2378	17638	18864	23896
1999	66	332	1409	3631	4442	-	1641	-	3495	2415	17430	18832	24120
2000	59	248	1707	3659	4834	-	1420	-	3173	2386	17486	19147	24271
2001	32	154	1214	3270	4980	-	2171	-	3487	2457	17764	18994	24422

Source: GfK Home Audit

Cavity wall insulation

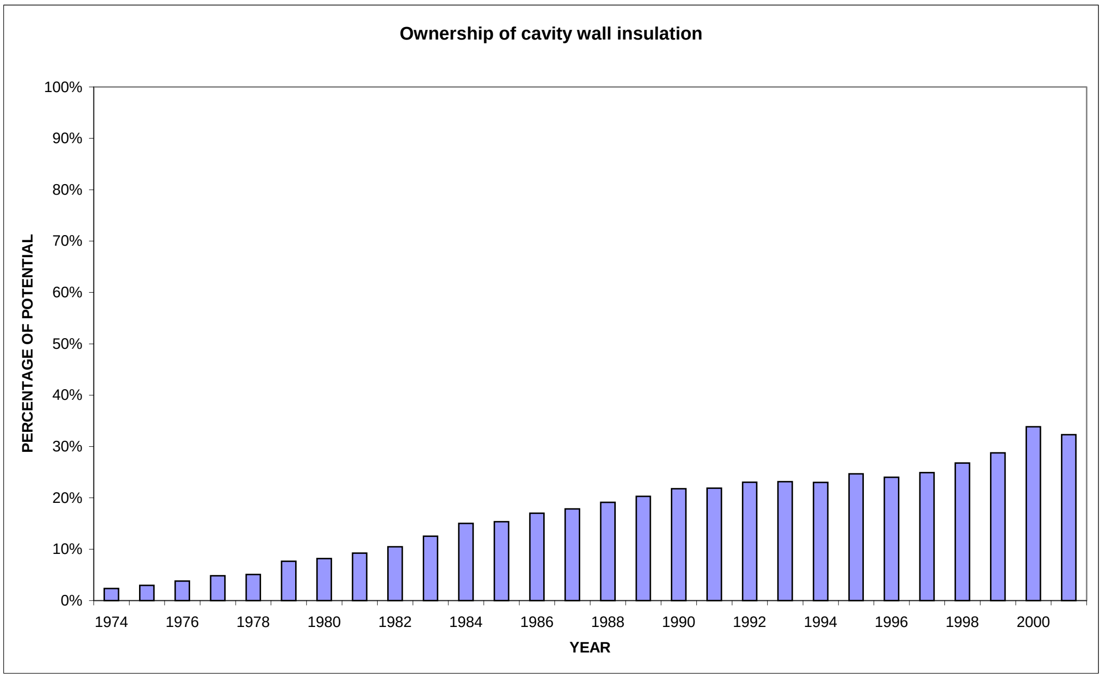


Figure 12. Ownership of cavity wall insulation

In 1974, 2.4% of cavity walled houses had cavity wall insulation. By 2001 this had risen to 32.3%. The increase in ownership levels seen since the mid-1990s is clearly related to the introduction of grants for this measure which first applied in 1994/95 and increased in numbers in subsequent years [2]. The fact that Building Regulations effectively required this measure has also been important in increasing ownership levels.

Table12 shows quite a high proportion of households who do not know if they have cavity wall insulation. Analysis of data between 1985 and 1992 on homes acquiring cavity wall insulation confirms the robustness of the assumption that if households don't know if they have cavity wall insulation it is likely that they don't have it. As the ownership level grows, however, this assumption obviously becomes increasingly less robust. In this regard, it is worth noting that since 1999 the proportion of "don't know" households has dropped significantly, due to a change to the routing of the questions on the survey questionnaire which has improved the response rate.

Most insulation has been added since the house was built. However, since the early 1990s new homes with cavity walls are likely to have been built with insulation because of the Building Regulations applicable at the time. The analysis for recent surveys has thus assumed that all cavity wall houses built since 1992 have cavity wall insulation.

The 1986 figure and later figures for dwellings with cavity walls in Table 12 have been derived directly from the GfK Home Audit data. The earlier figures for potential have been estimated by back projection from the 1986 figure.

Cavity wall insulation

Table 12. Ownership of cavity wall insulation (1,000s) - GB figures

Year	Houses with cavity insulation	Not known if cavity insulated	Potential	Total households
1974	295	-	12411	18783
1975	375	-	12570	18988
1976	485	-	12744	19215
1977	626	-	12938	19450
1978	674	-	13225	19650
1979	1029	-	13434	19827
1980	1115	-	13616	20010
1981	1275	-	13787	20177
1982	1464	-	13946	20327
1983	1773	-	14134	20525
1984	2156	-	14326	20769
1985	2230	2464	14515	21017
1986	2501	2623	14695	21254
1987	2672	2935	14951	21485
1988	2895	3070	15144	21710
1989	3150	3086	15514	21927
1990	3369	3448	15461	22140
1991	3475	3746	15874	22392
1992	3756	4198	16289	22595
1993	3653	3775	15767	22822
1994	3678	4673	15986	23076
1995	3970	4932	16086	23315
1996	4019	5544	16750	23492
1997	4193	5262	16832	23694
1998	4428	5054	16524	23896
1999	4869	1830	16922	24120
2000	5671	1855	16761	24271
2001	5646	2129	17477	24422

Source: GfK Home Audit

Double glazing ownership

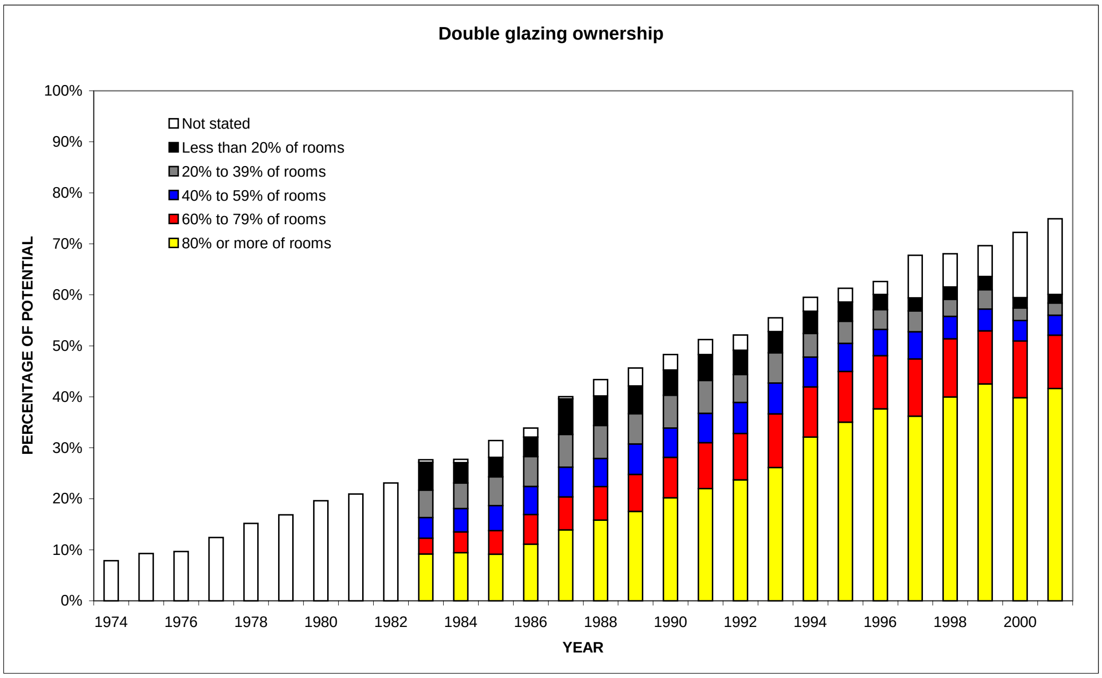


Figure 13. Double glazing ownership

Double glazing ownership has increased from 7.8% of households in 1974 to 74.9% in 2001. This uptake is more than twice the uptake for cavity wall insulation despite the cost of double glazing being considerably more.

Double glazing is rarely cost effective in terms of energy saving alone but it does have other benefits which are attractive to householders. When the windows have deteriorated to the point where they need replacing the extra expense of double glazing over single glazing is small enough to make the investment cost effective. Indeed, because double glazing has now become standard (it is required by Building Regulations) it nowadays costs no more than single glazing, and it will actually be less expensive in many cases. In fact, the 2002 revisions to the Building Regulations now require that double glazing is installed when windows are replaced, so the uptake of this measure should continue to grow strongly.

Additional information on the extent of double glazing, in terms of number of rooms treated, has been available since 1983. In 2001, 52.1% of households had at least 60% of rooms double glazed compared to 12.3% in 1983.

N.B. double glazing in this section includes both sealed units and windows with secondary glazing.

Double glazing ownership

Table 13. Double glazing ownership (1,000s) - GB figures

Year	Less than 20% of rooms	20% to 39% of rooms	40% to 59% of rooms	60% to 79% of rooms	80% or more of rooms	Not stated	Total with double glazing	Potential
1974	-	-	-	-	-	1473	1473	18783
1975	-	-	-	-	-	1763	1763	18988
1976	-	-	-	-	-	1856	1856	19215
1977	-	-	-	-	-	2414	2414	19450
1978	-	-	-	-	-	2980	2980	19650
1979	-	-	-	-	-	3339	3339	19827
1980	-	-	-	-	-	3926	3926	20010
1981	-	-	-	-	-	4222	4222	20177
1982	-	-	-	-	-	4695	4695	20327
1983	1126	1102	835	632	1884	97	5675	20525
1984	830	1042	952	848	1958	129	5758	20769
1985	804	1185	1032	970	1921	692	6604	21017
1986	819	1235	1169	1239	2360	378	7201	21254
1987	1499	1380	1258	1387	2986	90	8600	21485
1988	1252	1408	1195	1427	3436	700	9419	21710
1989	1198	1298	1311	1589	3844	769	10008	21927
1990	1096	1424	1270	1758	4470	671	10689	22140
1991	1138	1441	1291	2014	4924	661	11470	22392
1992	1076	1239	1375	2051	5361	671	11773	22595
1993	951	1357	1380	2397	5965	616	12666	22822
1994	1000	1075	1345	2271	7408	630	13729	23076
1995	877	1019	1283	2317	8165	630	14291	23315
1996	699	912	1208	2446	8848	591	14705	23492
1997	604	972	1260	2660	8576	1979	16051	23694
1998	573	804	1048	2728	9548	1558	16260	23896
1999	629	918	1025	2514	10257	1454	16798	24120
2000	493	596	972	2704	9664	3103	17531	24271
2001	418	582	950	2557	10165	3624	18296	24422

Source: GfK Home Audit

Draught proofing

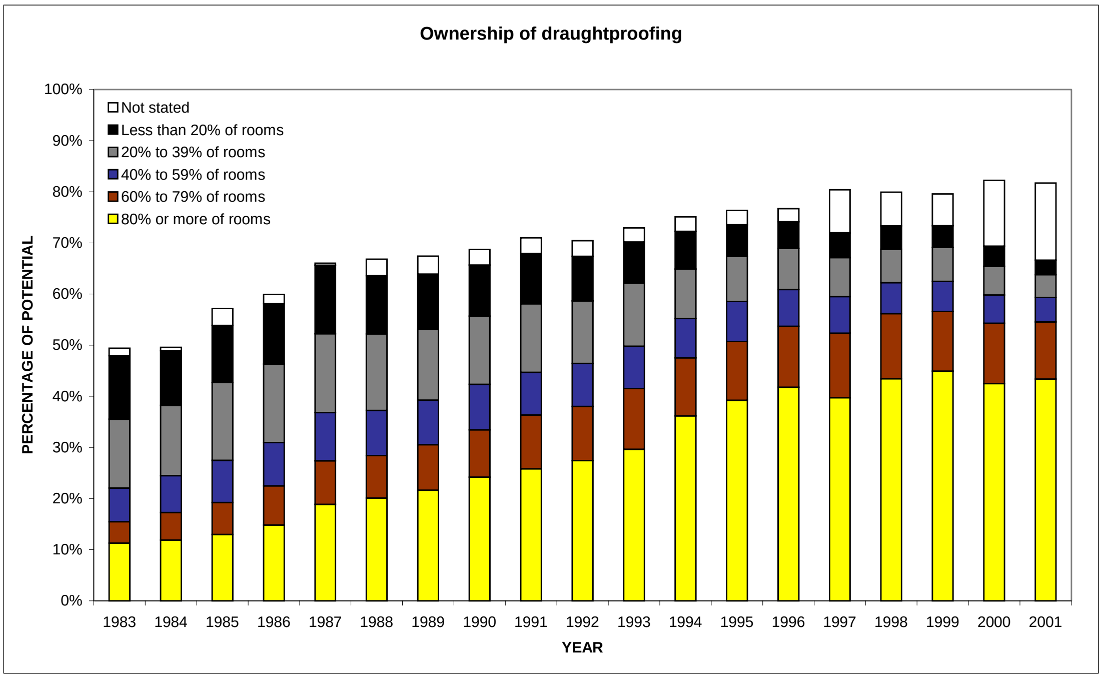


Figure 14. Ownership of draught proofing

Figure 14 shows the ownership of draught proofing. Draught proofing has been defined as including single glazed windows that have been draught stripped as well as double glazed windows (because double glazing incorporates integral draught seals).

Some households have both some double glazing and some draught stripping. It is necessary in these cases to do further analysis to determine whether they are one and the same thing. This can only be done for years after 1987 where the data for the necessary cross tabulations are available. Fortunately the number of such cases is small so their exclusion in earlier years does not distort the general trend.

In 1983, 49.4% of households had some draught proofing and 15.4% had at least 60% of rooms draught proofed. By 2001 this had increased to 81.7% with some draught proofing and 54.5% with at least 60% of rooms draught proofed.

The continuing strong uptake of double glazing should ensure that draught proofing ownership, as defined here, will also carry on growing.

Draught proofing

Table 14. Ownership of draughtproofing (1,000s) - GB figures

Year	Less than 20% of rooms	20% to 39% of rooms	40% to 59% of rooms	60% to 79% of rooms	80% or more of rooms	Not stated	Total with draught proofing	Potential
1983	2546	2767	1358	854	2316	296	10138	20525
1984	2227	2852	1496	1119	2471	134	10298	20769
1985	2348	3198	1735	1318	2725	692	12016	21017
1986	2513	3266	1798	1631	3149	378	12734	21254
1987	2876	3319	2026	1829	4050	90	14190	21485
1988	2470	3249	1911	1802	4367	700	14500	21710
1989	2362	3044	1911	1948	4745	769	14779	21927
1990	2218	2948	1971	2052	5352	671	15212	22140
1991	2215	2997	1867	2357	5781	678	15895	22392
1992	1973	2767	1901	2391	6194	688	15914	22595
1993	1838	2811	1891	2711	6763	636	16650	22822
1994	1701	2232	1774	2620	8348	655	17329	23076
1995	1449	2051	1826	2679	9145	650	17800	23315
1996	1224	1896	1692	2796	9814	600	18023	23492
1997	1154	1806	1697	2986	9413	1995	19050	23694
1998	1094	1558	1449	3042	10380	1573	19096	23896
1999	1028	1603	1421	2807	10840	1493	19192	24120
2000	953	1365	1337	2873	10308	3119	19955	24271
2001	692	1098	1166	2725	10593	3676	19951	24422

Source: GfK Home Audit

Insulation ownership

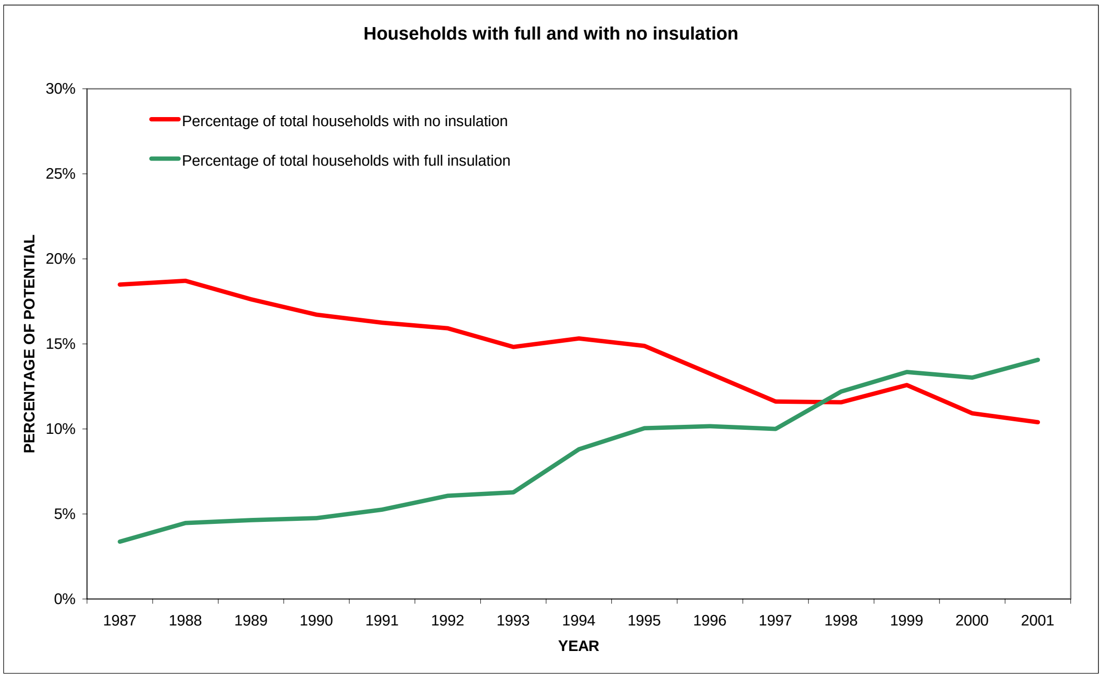


Figure 15. Households with full and with no insulation

The previous charts have shown how individual fabric insulation measures to increase energy efficiency have been adopted over the last 20 to 30 years. In Figure 15 we can see how these measures combine. It shows the percentage of dwellings with full insulation and no insulation.

Full insulation is defined as:	At least 4” of loft insulation where there is a loft Cavity walls insulated if there is a cavity At least 80% of windows double glazed
No insulation is defined as:	No loft insulation where there is a loft No cavity wall insulation where there is a cavity No double glazing

On these definitions 18.5% of dwellings had no insulation and 3.4% had full insulation in 1987, which is the first year that figures are available. By 2001 the percentage of dwellings with no insulation had fallen to 10.4% and the number with full insulation had risen to 14.1%.

The numbers with full insulation still represent a comparatively small, but growing, proportion of the housing stock. However, the proportion is very much greater for newer homes. For houses built from 1990 onwards 35.4% had full insulation in 2001. The new Building Regulations for 2002 mean that the vast majority of future dwellings will have full insulation according to the above definitions so the increasing trend seen above will undoubtedly continue and will probably accelerate.

Insulation ownership

Table 15. Households with full and no insulation measures - GB figures

Year	total households with no insulation	total households with full insulation	total households
1987	3971	724	21485
1988	4061	970	21710
1989	3864	1018	21927
1990	3701	1053	22140
1991	3638	1177	22392
1992	3596	1372	22595
1993	3383	1430	22822
1994	3535	2032	23076
1995	3469	2341	23315
1996	3114	2388	23492
1997	2751	2370	23694
1998	2764	2915	23896
1999	3034	3220	24120
2000	2649	3160	24271
2001	2538	3433	24422

Source: GfK Home Audit

6 Hot water tank insulation and instantaneous water heaters

Main trends

Whilst the insulation levels in the fabric of the average house have been increasing there has also been an increase in the insulation of hot water tanks. This has occurred in two different ways. Firstly, through the addition of hot water cylinder jackets, the thickness of which has progressively increased with time as insulation standards generally have been raised. More recently, however, the replacement of hot water cylinders with new cylinders that incorporate a factory bonded layer of foam insulation has been increasingly popular.

Insulating hot water tanks obviously reduces the energy needed for water heating, but by reducing the heat losses from the tank to the dwelling it actually results in a very slight increase to the space heating requirements.

Instantaneous water heaters

In recent years the number of homes that have no hot water tank has begun to increase quite markedly, thereby reducing the potential for tank insulation. Various forms of instantaneous water heating exist but it is clear that this trend is being driven by the increasing popularity of combi boilers. Central heating systems using combi boilers do not have hot water cylinders (although the boiler unit itself generally incorporates a small integral store).

Hot water tank insulation

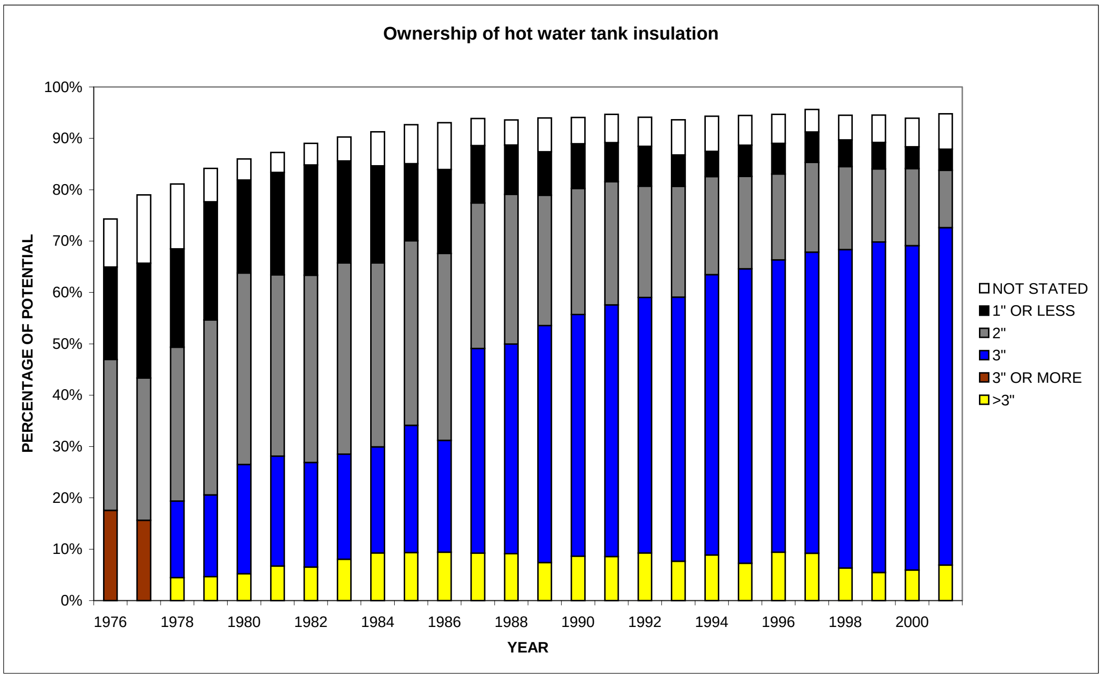


Figure 16. Ownership of hot water tank insulation

The energy efficiency measures considered so far are all measures which affect the heat loss through the fabric of the house. The insulation of hot water tanks is different in that it affects the heat loss from the tank and hence the cost of providing hot water. A decrease in heat lost from the hot water tank can result in an increase in the energy necessary to heat the house.

Insulation of the hot water tank is, however, a very cost effective measure. It is cheap and simple to install and usually pays back within a year.

In 1976, 74.3% of potential households had hot water tank insulation. By 2001 this had risen to 94.8% of potential households and the market appears to be close to saturation.

Many tanks are now factory insulated. These normally have about 1 inch of insulation but this is equivalent to a 3 inch thickness of standard cylinder jacket insulation. Prior to 1987 such insulation was recorded as the estimated actual thickness but since 1987 it has been recorded as 3 inches to better reflect the true insulation properties. This is the reason for the slight discontinuity in 1987 that is evident in Figure 16.

Not all dwellings have hot water tanks as in some water is heated by instantaneous water heaters. The potential is therefore less than the total number of households. Since the mid-1980s the potential has been falling relative to the total number of households and this is clearly related to the introduction of combi boilers (see Figure 17).

Hot water tank insulation

Table 16. Ownership of hot water tank insulation (1,000s) - GB figures

Year	1" or less	2"	3"	3" or more	>3"	Not stated	Total with	Potential	Total households
1976	2988	4870	-	2918	-	1552	12328	16588	19215
1977	3751	4660	-	2625	-	2240	13277	16804	19450
1978	3211	5025	2505	-	750	2124	13615	16783	19650
1979	3982	5892	2754	-	809	1126	14563	17305	19827
1980	3182	6554	3742	-	919	718	15116	17579	20010
1981	3484	6165	3741	-	1176	677	15243	17471	20177
1982	3785	6428	3593	-	1154	742	15701	17639	20327
1983	3594	6745	3706	-	1460	843	16348	18116	20525
1984	3494	6625	3816	-	1716	1227	16878	18489	20769
1985	2870	6877	4742	-	1791	1457	17737	19139	21017
1986	3158	7025	4203	-	1822	1756	17964	19307	21254
1987	2197	5539	7804	-	1811	1026	18377	19581	21485
1988	1900	5777	8075	-	1814	963	18528	19803	21710
1989	1687	5044	9182	-	1473	1308	18694	19893	21927
1990	1749	4925	9440	-	1731	1022	18867	20059	22140
1991	1535	4842	9899	-	1731	1111	19117	20194	22392
1992	1555	4322	9924	-	1854	1122	18778	19956	22595
1993	1225	4330	10321	-	1536	1370	18783	20068	22822
1994	988	3843	10977	-	1786	1377	18971	20113	23076
1995	1214	3606	11487	-	1455	1160	18921	20035	23315
1996	1186	3310	11266	-	1865	1117	18743	19797	23492
1997	1203	3535	11876	-	1862	881	19357	20246	23694
1998	1031	3206	12281	-	1262	954	18732	19821	23896
1999	987	2737	12375	-	1056	1025	18179	19234	24120
2000	820	2906	12232	-	1152	1080	18189	19363	24271
2001	769	2103	12343	-	1300	1293	17807	18789	24422

Source: GfK Home Audit

Instantaneous water heaters

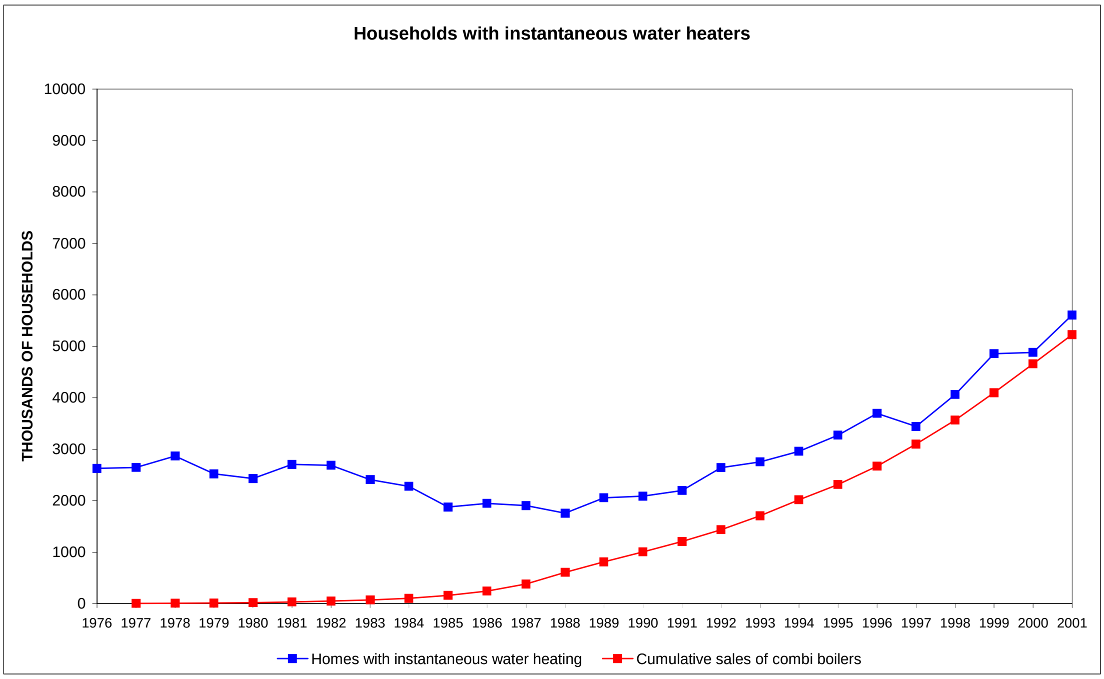


Figure 17. Households with instantaneous water heaters

Figure 17 shows how the number of dwellings with instantaneous water heaters has grown since the mid 1980s. Prior to this, the numbers with instantaneous water heating were falling as people replaced old appliances with hot water tanks heated by modern conventional central heating systems.

The increase since the mid 1980s is clearly linked to the growing popularity of combi boilers, as indicated by the cumulative combi boiler sales figures. Combi boilers, which dispense with the need for a hot water tank, represented almost 50% of gas boiler sales in 2001 so the trend towards increased instantaneous water heating looks set to continue.

In terms of energy efficiency this is a positive trend because it does away with the inevitable losses associated with storing large amounts of hot water, and combi boilers are relatively efficient as well. Even so, there are practical concerns in some quarters related to potential scale build-up problems, particularly in hard water areas. These could mean that the lifetimes of such boilers will in practice be limited.

Instantaneous water heaters

Table 17. Hot water tank ownership (1,000s) - GB figures (UK figures for boiler sales)

Year	All homes	With no tank	With a tank	Combi boiler sales figures (BSRIA)	Cumulative combi boiler sales
1976	19215	2627	16588		
1977	19450	2646	16804	3	3
1978	19650	2867	16783	4	7
1979	19827	2522	17305	5	12
1980	20010	2431	17579	6	18
1981	20177	2706	17471	13	31
1982	20327	2688	17639	19	50
1983	20525	2409	18116	20	70
1984	20769	2280	18489	32	102
1985	21017	1878	19139	55	157
1986	21254	1947	19307	87	244
1987	21485	1903	19582	138	382
1988	21710	1758	19952	225	607
1989	21927	2058	19869	205	812
1990	22140	2088	20052	195	1007
1991	22392	2198	20194	200	1207
1992	22612	2641	19971	230	1437
1993	22832	2755	20077	270	1707
1994	23052	2959	20093	310	2017
1995	23272	3274	19998	298	2315
1996	23492	3695	19797	355	2670
1997	23656	3442	20213	430	3100
1998	23819	4062	19757	465	3565
1999	23983	4858	19125	534	4099
2000	24146	4883	19264	560	4659
2001	24310	5607	18703	570	5229

Source: GfK Home Audit
BSRIA

7 Energy consumption

Main trends

This section presents overall trends in energy consumption in the context of the variables which affect it. The effects are summed up in Figure 27 and Table 27 – 'the effect of energy efficiency improvements'. The improvements are also summarised in terms of an energy rating for the average dwelling in Figure 28 and Table 28.

External temperatures, heat loss and energy consumption

Space heating accounts for the major part of energy used in the average home. The strength of the relationship between domestic energy consumption and external temperature depends on the proportion of energy use which is for space heating. This, in turn, depends on the heat loss of the average dwelling. As the heat loss reduces, a greater proportion of the total energy use goes towards end uses which are not related (or at least not strongly related) to external temperature.

The quantity of energy required for space heating is related to external temperature. The insulation measures covered in sections 5 and 6 will have affected only space heating and water heating consumptions. Tank insulation acts to reduce water heating consumption whilst the other insulation measures reduce space heating consumption. A large part of the improvement in average house heat loss is attributable to loft insulation. Since loft insulation is now reaching a saturation level, it is not surprising to see that the rate of improvement has declined over recent years. There is, however, considerable scope for future acceleration of the rate of improvement through other insulation measures – particularly cavity wall insulation and double glazing and the figures for recent years do suggest the start of such acceleration.

Central heating and increased comfort levels

Other things being equal, space heating would have increased with the increasing proportion of houses having central heating (see Figure 20 and Table 20) and with growing expectations of comfort in both centrally heated and non-centrally heated homes (see Figure 26 and Table 26). The trend towards more central heating and higher comfort levels will probably continue until such time as a saturation level is reached, corresponding to the attainment of desired levels of comfort by all households.

Despite the growth in the ownership of central heating and increased standards of comfort, space heating energy consumption per household has hardly changed over the period under consideration (see Table 25)

Efficiency of appliances

The rising trends have been offset by better standards of insulation (detailed in section 5 and summarised in Figure 19) and improved heating appliance efficiencies (see Figure 24). There has also been an increase in the incidental gains from appliances which has further helped to offset space heating energy requirements.

Total energy consumption figures include energy that has been used for space heating, water heating, cooking, lighting and the running of electrical appliances. All these categories of energy consumption will have been affected by the increasing numbers of households and by the improvements in the efficiencies of appliances. Increasing numbers of households will have tended to raise consumption but improving efficiencies will have acted to reduce consumption.

The delivered energy requirement of houses has undoubtedly been reduced by improvements in the efficiencies of heating appliances. It is difficult to quantify precisely this improvement in terms of an average efficiency in1970 compared with an average efficiency calculated on the same basis in 2001. Table 24 attempts to do this. However, before considering this table, it is necessary to look briefly at what is known about improvements to heating appliance efficiencies. The discussion focuses on gas appliances because gas is the most used fuel for heating and so has the greatest influence on overall changes to heating efficiency. Also, detailed data on some other forms of heating is rather sparse.

British Gas have published data on the full load efficiencies of central heating boilers submitted for approval. Although there is considerable scatter in such measurements there has been a clear trend towards improving efficiencies. The average full load efficiency of boilers assessed in 1970 was about 73%. By 1984 this had risen to 78%. A modern conventional boiler might achieve a full load efficiency of 80% - which is close to the limit of such a boiler. Although modern conventional boiler full load efficiencies are probably near their limit now it seems likely that the trend towards improving efficiencies will continue through the introduction of condensing boilers (see Table 23) which have full load efficiencies of about 90%.

There have been similar improvements in the full load efficiencies of gas fires which have risen at an average rate of 0.7% per annum between 1970 and 1986. Here too, the improvement looks likely to continue with the introduction of condensing appliances.

The full load efficiencies of new appliances are, of course, not properly representative of the average efficiencies achieved by existing appliances in use in the housing stock now. These efficiencies will be lower because, in general, the existing appliances will have somewhat lower full load efficiencies than new appliances and because the operation of the appliances is necessarily at part load. The efficiency of a conventional boiler decreases quite substantially as the load is progressively reduced, although this effect is less marked for modern boilers. Unlike conventional boilers, however, condensing boilers have part load efficiencies which are close to their full load efficiencies.

Over the past few years much work has been done on characterising the in-use efficiencies of boilers in connection with the Standard Assessment Procedure [7]. There is now a database for all gas and oil boilers (both current and obsolete) that may be accessed on the internet at *www.boilers.org.uk.* This has led, through work for the Market Transformation Programme, to a boiler model for the housing stock. This model contains information on historical efficiencies and when fed with assumptions about future trends it provides estimates of future efficiencies. The historical information from this model has been used to update and revise the average heating efficiency figures that are presented in this section.

Basis of calculations – BREHOMES

To investigate the interaction between the above factors, the Building Research Establishment Housing Model for Energy Studies (BREHOMES) has been used. Some of the tables in this section rely on the analyses of that model. The BREHOMES model has been used to calculate the heat losses of different types of dwelling for twenty of the years between 1970 and 2001. These calculations have used the same information that is presented in section 5. The BREHOMES calculations of heat loss rely on factual statistical data where it exists, but, inevitably, some assumptions have to be made where the available data is less robust. In future, it is possible that such data will be improved upon, which might lead to slight revisions of the calculated heat loss figures.

Although the detailed calculations have only been done for twenty of the years between 1970 and 2001, this is sufficient to be able to make good estimates for all years, thereby forming a continuous series.

End uses

Among the following tables there is one (Table 25) which gives a breakdown of domestic energy consumption between the categories of end use mentioned above – space heating, water heating, cooking and lighting and appliances. This table is a little more tentative than some of the others for a number of reasons. Firstly, there is no factual statistical source on which one can base such figures. By using BREHOMES, however, it is possible to make informed estimates.

Even so, it has to be recognised that the categorisation of end uses is not unequivocal. For example, because space and water heating are often supplied using the same appliance, there is no uniquely correct way of allocating the total consumption of that appliance between space heating and water heating. Any such allocation is largely a matter of definition or convention. The numbers in Table 25 need to be viewed with this in mind – they are indicative rather than definitive figures.

Energy consumption and external temperatures

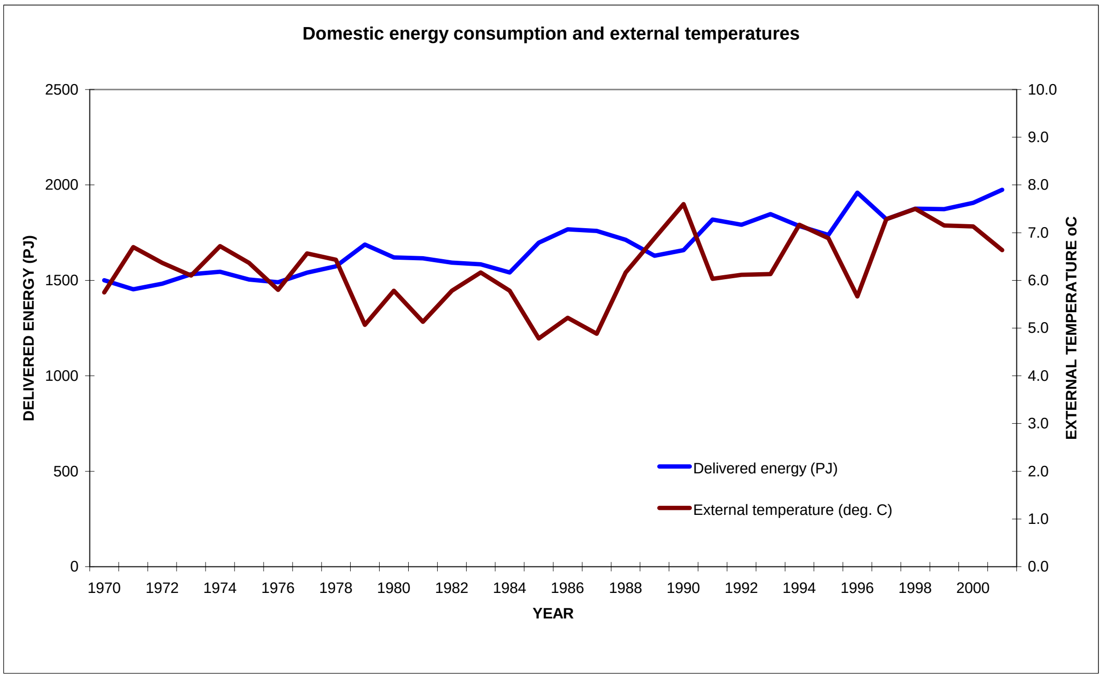


Figure 18. Domestic energy consumption and external temperatures

Figure 18 shows the relationship between domestic energy consumption and external temperature. The lowest temperatures generally correspond with the peaks in energy consumption. The effect of the cold winters of 1979, 1985, 1986, 1987 and 1996 can be seen.

Table 18 also shows the average consumption per dwelling. Between 1970 and 2001 domestic energy consumption rose by 31.5%. In the same period the number of households rose by 35.8% so the average consumption per dwelling has actually fallen. But the average external temperature in 2001 was higher than in 1970 so, all other things being equal, we would have expected a lower average energy consumption in 2001. However, “all other things being equal” has most certainly not been the case as the following figures and tables will illustrate.

Energy consumption and external temperatures

Table 18. Domestic energy consumption and external temperatures - GB figures

Year	Total houses (1,000s)	Total delivered energy (PJ)	Average external temperature (^oC)	Average consumption per dwelling (GJ)
1970	17987	1501	5.8	83.5
1971	18221	1453	6.7	79.7
1972	18426	1482	6.4	80.4
1973	18603	1532	6.1	82.3
1974	18783	1545	6.7	82.2
1975	18988	1505	6.4	79.1
1976	19215	1490	5.8	77.5
1977	19450	1540	6.6	79.1
1978	19650	1574	6.4	80.0
1979	19827	1688	5.1	85.0
1980	20010	1621	5.8	80.9
1981	20177	1616	5.1	80.0
1982	20327	1593	5.8	78.3
1983	20525	1585	6.2	77.2
1984	20769	1542	5.8	74.2
1985	21017	1697	4.8	80.7
1986	21254	1768	5.2	83.2
1987	21485	1759	4.9	81.9
1988	21710	1713	6.2	78.9
1989	21927	1629	6.9	74.3
1990	22140	1658	7.6	74.9
1991	22392	1819	6.0	81.3
1992	22595	1792	6.1	79.3
1993	22822	1848	6.1	81.0
1994	23076	1785	7.2	77.3
1995	23315	1738	6.9	74.6
1996	23492	1959	5.7	83.4
1997	23694	1821	7.3	76.9
1998	23896	1875	7.5	78.5
1999	24120	1873	7.2	77.7
2000	24271	1907	7.1	78.6
2001	24422	1974	6.6	80.8

Source: Digest of United Kingdom Energy Statistics

Heat loss of the average dwelling

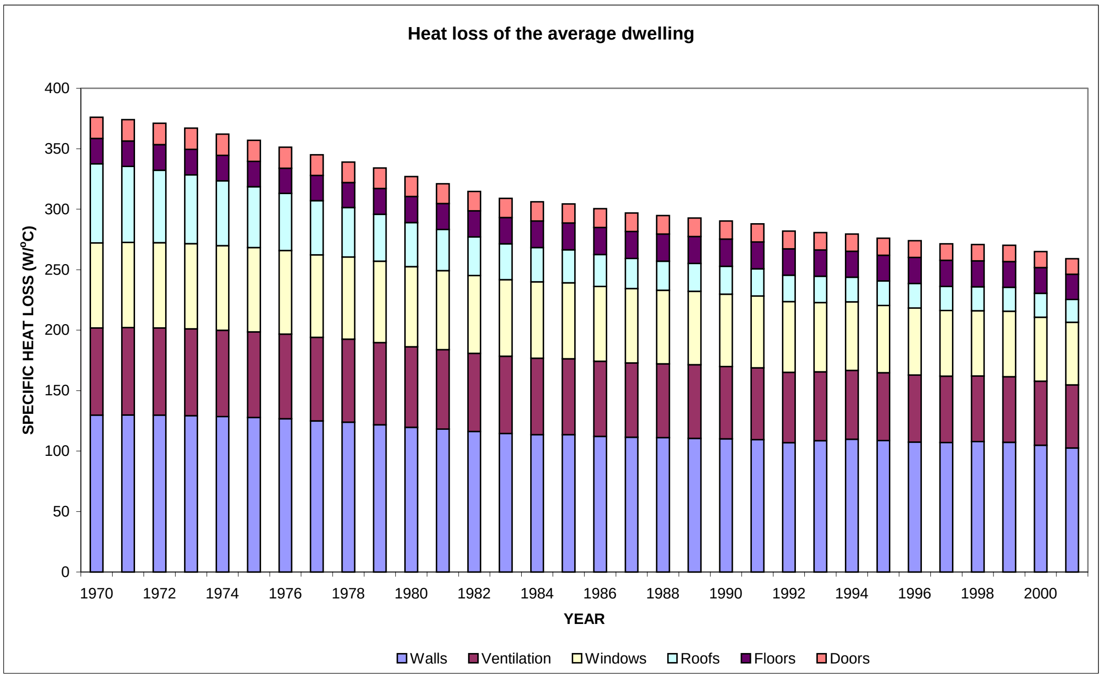


Figure 19. Heat loss of the average dwelling

Values for the heat loss of the average dwelling are shown in Figure 19 and Table 19. These figures have been calculated using the BREHOMES model and they show how the heat loss of the average dwelling has improved considerably over the years.

The rate of heat loss of a dwelling is usually expressed as the specific rate in Watts per degree Celsius of difference in temperature between internal and external environments; hence the notation W/^{o}C in Figure 19 and Table 19. As indicated in the figure and table, the specific heat loss rate includes both losses through the fabric of the dwelling and ventilation losses. The term *specific heat loss* is commonly replaced, for the sake of brevity, by *heat loss*. This practice has been adopted throughout the *Domestic Energy Fact File*.

Space heating energy consumption is not directly proportional to heat loss. This is mainly because of the contribution which is made to meeting the space heating requirement by other sources of heat. These sources of heat consist of the free gains from other energy uses (heat from electrical appliances, cookers, etc.) and natural gains (heat from the dwelling occupants and from solar energy). If these free gains were to remain constant then a given reduction in dwelling heat loss would result in a more than proportionate decrease in the heat supplied by the space heating system. The BREHOMES model suggests that a 1% reduction in dwelling heat loss typically results in a 1.5% reduction in the heat supplied by the space heating system.

The final column of Table 19 shows the heat loss of the entire housing stock. The stock heat loss begins to fall from the early 1970s, but since the early 1980s it has changed little – implying that the rate of improvement to the insulation standards of the stock is only just keeping pace with the tendency towards an overall larger heat loss due to the growth of the stock. However, the figures in Table 19 for the most recent years do suggest that the rate of improvement is starting to accelerate again.

Heat loss of the average dwelling

Table 19. Heat loss of the average dwelling and the whole stock - GB figures

	Average dwelling heat loss by building element (W/ºC)							
Year	Walls	Ventilation	Windows	Roofs	Floors	Doors	Average dwelling heat loss (W/^{o}C)	Stock loss (GW/ºC)
1970	129.7	72.1	70.2	65.4	21.0	17.5	376.0	6.76
1971	129.8	72.2	70.4	62.8	21.1	17.6	374.0	6.81
1972	129.7	72.2	70.5	59.9	21.1	17.6	371.0	6.84
1973	129.2	71.9	70.4	56.8	21.1	17.6	367.0	6.83
1974	128.4	71.4	70.1	53.6	21.1	17.5	362.0	6.80
1975	127.7	70.8	69.7	50.4	21.0	17.4	357.0	6.78
1976	126.7	70.1	69.1	47.2	20.9	17.3	351.2	6.75
1977	124.8	69.2	68.3	44.7	20.9	17.1	345.0	6.71
1978	123.8	68.7	68.0	40.8	20.7	17.0	339.0	6.66
1979	121.7	68.0	67.4	38.7	21.4	16.8	334.0	6.62
1980	119.6	66.7	66.2	36.4	21.6	16.5	327.0	6.54
1981	118.1	65.7	65.3	34.0	21.5	16.3	321.0	6.48
1982	116.2	64.6	64.3	31.9	21.6	16.1	314.7	6.40
1983	114.6	63.8	63.2	29.7	21.7	15.9	309.0	6.34
1984	113.5	63.3	63.1	28.3	22.1	15.8	306.1	6.36
1985	113.4	62.9	62.8	27.3	22.2	15.7	304.3	6.40
1986	112.1	62.0	62.1	26.3	22.4	15.5	300.4	6.38
1987	111.4	61.4	61.4	25.0	22.3	15.4	296.9	6.38
1988	111.1	61.0	60.8	23.9	22.5	15.3	294.7	6.40
1989	110.5	60.8	60.7	23.1	22.2	15.2	292.6	6.42
1990	110.0	59.8	59.7	23.1	22.5	15.0	290.2	6.43
1991	109.5	59.4	59.4	22.5	22.2	14.9	287.8	6.44
1992	106.9	58.2	58.5	21.9	21.8	14.6	281.8	6.37
1993	108.5	57.0	57.2	21.8	21.8	14.3	280.6	6.40
1994	109.7	57.0	56.7	20.4	21.5	14.3	279.5	6.45
1995	108.6	56.1	55.8	20.2	21.3	14.0	276.0	6.43
1996	107.3	55.6	55.4	20.2	21.5	13.9	274.0	6.44
1997	107.0	54.9	54.3	19.9	21.6	13.7	271.4	6.43
1998	107.8	54.2	53.9	19.9	21.4	13.5	270.8	6.47
1999	107.2	54.2	54.2	19.7	21.3	13.5	270.2	6.52
2000	104.8	53.0	52.8	19.9	21.3	13.2	264.9	6.43
2001	102.6	52.1	51.8	18.8	20.8	13.0	259.1	6.33

Source: BREHOMES

Figures for 1970 to 1975, 1977 to 1981, and 1983 have been determined by interpolation and extrapolation. Full heat loss calculations have been performed for all other years.

Central heating ownership

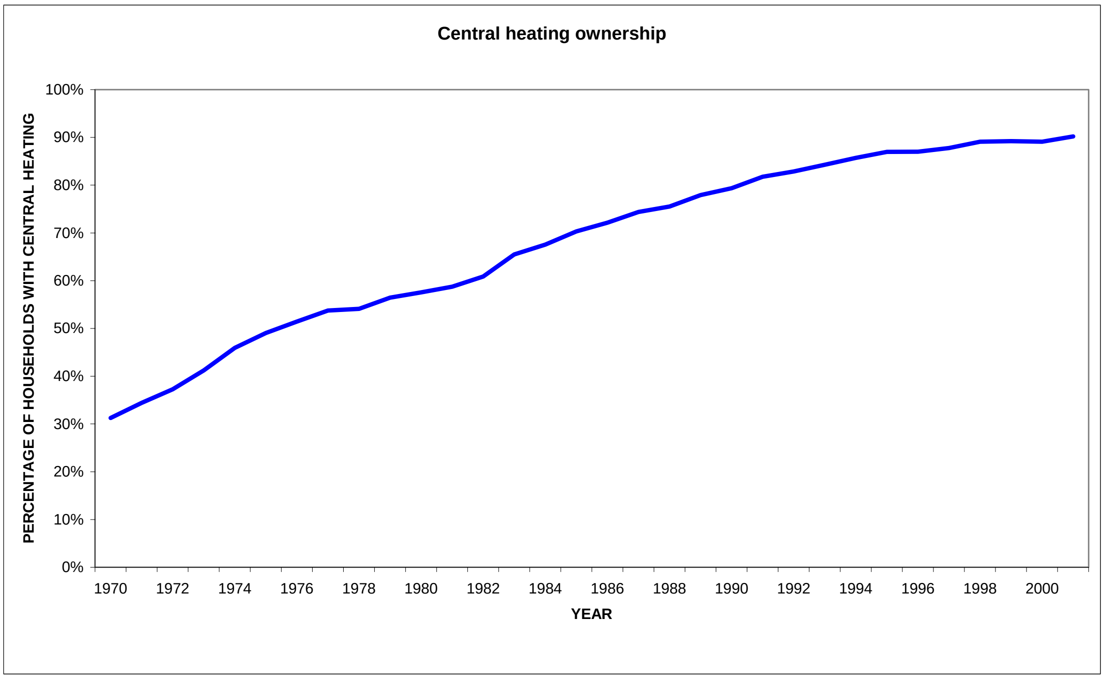


Figure 20. Central heating ownership

Only 31% of homes had central heating in 1970. By 2001 this had risen to 90%.

Central heating appliances are generally more efficient than individual room appliances so, for a given requirement for useful space heat in a dwelling, they would be expected to use less delivered energy.

However, installation of central heating is usually associated with a considerable increase in the occupant's comfort expectation, particularly in respect of the number of rooms heated – and hence an increase in the useful heat requirement. As a result, unless there is a concurrent improvement in insulation, an average centrally heated house would require about twice as much delivered energy for space heating as would a similar house in which only the living room is heated.

This proportion would be higher for a house with poor levels of insulation. On the other hand, it would be lower for a well insulated house where heat transfer from the living room can often achieve comfort temperatures throughout the house. In a very well insulated house, therefore, it may only be necessary to install a simple system of one or two room heaters instead of a full central heating system.

Central heating ownership

Table 20. Central heating ownership (1,000s) - GB figures

Year	No central heating	With central heating	Total households
1970	12359	5628	17987
1971	11950	6271	18221
1972	11559	6867	18426
1973	10934	7669	18603
1974	10155	8628	18783
1975	9673	9315	18988
1976	9327	9888	19215
1977	8996	10454	19450
1978	9017	10633	19650
1979	8635	11192	19827
1980	8493	11517	20010
1981	8326	11851	20177
1982	7953	12374	20327
1983	7082	13443	20525
1984	6740	14029	20769
1985	6239	14778	21017
1986	5917	15337	21254
1987	5504	15981	21485
1988	5314	16396	21710
1989	4838	17089	21927
1990	4567	17573	22140
1991	4083	18309	22392
1992	3868	18727	22595
1993	3593	19229	22822
1994	3294	19782	23076
1995	3041	20274	23315
1996	3054	20438	23492
1997	2903	20791	23694
1998	2602	21294	23896
1999	2603	21517	24120
2000	2646	21625	24271
2001	2392	22030	24422

Source: GfK Home Audit

Heating appliances and efficiencies – central heating

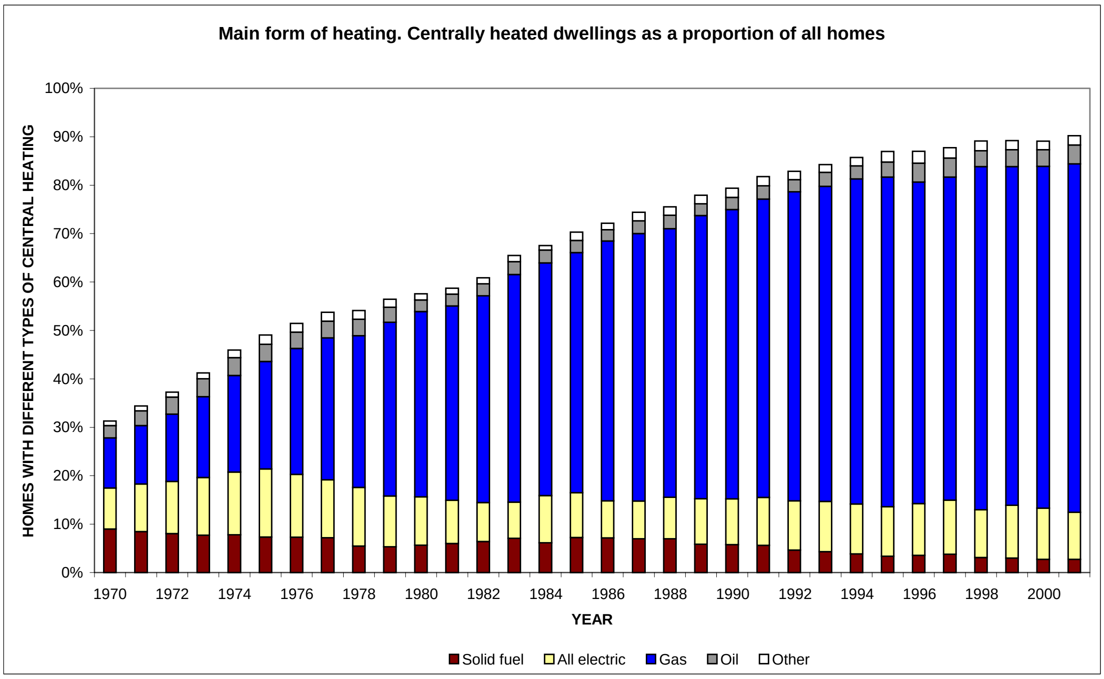


Figure 21. Main form of heating. Centrally heated homes as a proportion of all homes

Figure 21 shows the percentage of homes which are centrally heated by the different types of fuel. The overall growth in central heating ownership can be seen to have been largely driven by the massive increase in gas central heating.

The ownership of gas-fired appliances has increased from 33% of centrally heated dwellings in 1970 to over 80% in 2001. In contrast, the use of solid fuel central heating shows a marked decline from 29% of the total households with central heating in 1970 to only 3% in 2001.

The growth in gas central heating has brought with it a considerable improvement in the average heating efficiency (see Figure 24 and Table 24).

Heating appliances and efficiencies – central heating

Table 21. Main form of heating – centrally heated dwellings (1,000s) - GB figures

Year	Solid fuel	Electric storage	Electric other	All electric	Gas	Oil	Other	Total
1970	1615	1094	436	1529	1856	460	167	5628
1971	1543	1280	510	1789	2201	555	184	6271
1972	1483	1417	564	1981	2563	649	189	6867
1973	1434	1577	640	2217	3109	685	225	7669
1974	1461	1733	703	2436	3747	688	295	8628
1975	1394	1869	803	2672	4213	676	360	9315
1976	1407	1739	747	2486	5003	647	345	9888
1977	1398	1626	698	2324	5704	671	357	10454
1978	1073	1665	715	2380	6160	666	354	10633
1979	1052	1457	626	2083	7113	615	328	11192
1980	1134	1395	599	1994	7655	478	255	11517
1981	1209	1219	580	1799	8102	488	252	11851
1982	1303	1065	570	1635	8677	505	253	12374
1983	1457	947	584	1531	9644	545	265	13443
1984	1273	1319	708	2027	9977	552	199	14029
1985	1521	1313	632	1945	10422	528	363	14778
1986	1523	1154	466	1620	11414	490	291	15337
1987	1499	1267	404	1671	11871	565	375	15981
1988	1515	1384	474	1858	12050	600	372	16396
1989	1284	1513	545	2058	12821	535	392	17089
1990	1277	1641	454	2095	13223	557	421	17573
1991	1262	1802	413	2215	13790	620	421	18309
1992	1047	1881	420	2301	14419	569	391	18727
1993	982	1991	376	2367	14850	659	371	19229
1994	890	1910	468	2378	15490	626	397	19782
1995	786	1994	395	2389	15870	721	507	20274
1996	840	2113	390	2503	15608	915	572	20438
1997	896	2249	400	2650	15803	932	510	20791
1998	740	2105	256	2361	16932	780	481	21294
1999	721	2172	465	2637	16862	842	456	21517
2000	665	2131	434	2565	17125	837	433	21625
2001	666	1947	428	2375	17577	946	466	22030

Source: GfK Home Audit

Heading appliances and efficiencies – non central heating

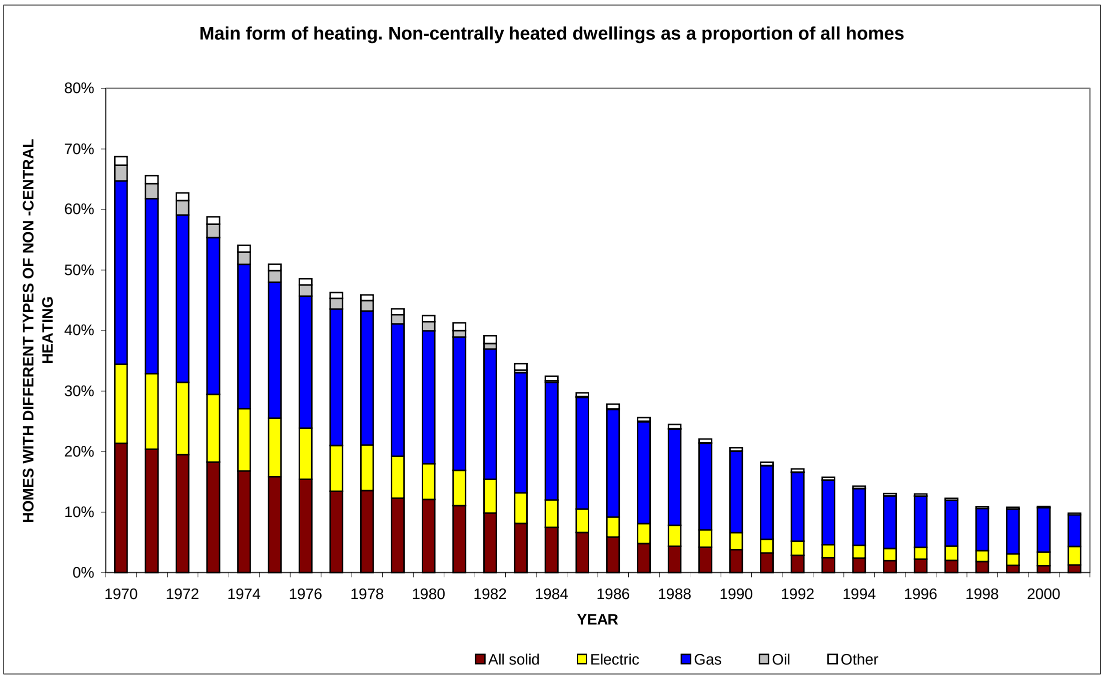


Figure 22. Main form of heating. Non-centrally heated homes as a proportion of all homes

The number of non-centrally heated homes has fallen steadily between 1970 and 2001. In 2001 only 9.8% of the stock was non-centrally heated, compared to 68.7% in 1970.

The figures clearly show that use of all forms of non-central heating has declined. However, as a proportion the numbers using gas has grown from 44% of non-centrally heated homes in 1970 to 53% in 2001. Thus, the growing preference for gas as a heating fuel that was seen in the figures for centrally heated homes has also been reflected in the figures for non-centrally heated homes.

Heating appliances and efficiencies – non central heating

Table 22. Main form of heating – non centrally heated dwellings (1,000s) - GB figures

Year	Solid fuel fire	Solid fuel stove	All solid	Electric	Gas	Oil	Other	Total
1970	3221	619	3840	2351	5447	469	251	12359
1971	3115	599	3714	2274	5266	454	242	11950
1972	3013	580	3593	2199	5094	439	235	11559
1973	2850	548	3398	2080	4819	415	222	10934
1974	2647	508	3155	1931	4477	386	206	10155
1975	2521	485	3006	1840	4262	368	197	9673
1976	2485	478	2963	1621	4191	360	192	9327
1977	2194	421	2615	1466	4386	345	184	8996
1978	2232	429	2661	1478	4349	344	184	9017
1979	1827	612	2439	1372	4333	304	188	8635
1980	1735	680	2415	1182	4393	301	203	8493
1981	1630	604	2234	1173	4447	212	260	8326
1982	1383	614	1997	1133	4381	178	264	7953
1983	1048	622	1670	1033	4074	92	213	7082
1984	988	566	1554	938	4033	56	159	6740
1985	895	495	1390	813	3876	32	127	6239
1986	811	436	1247	700	3781	22	166	5917
1987	671	360	1030	710	3605	25	133	5504
1988	613	330	943	748	3450	23	150	5314
1989	597	321	917	630	3136	16	138	4838
1990	543	292	835	628	2978	7	121	4567
1991	473	255	728	503	2718	15	119	4083
1992	417	224	641	529	2572	10	115	3868
1993	366	197	563	486	2434	6	104	3593
1994	359	193	552	486	2169	3	84	3294
1995	300	161	461	471	2019	7	83	3041
1996	338	182	519	463	1986	4	81	3054
1997	309	166	475	563	1797	3	65	2903
1998	283	152	435	433	1662	2	69	2602
1999	190	102	293	449	1791	5	66	2603
2000	178	96	274	547	1775	2	48	2646
2001	198	107	305	747	1275	0	63	2392

Source: GfK Home Audit

Heating appliances and efficiencies – condensing boilers

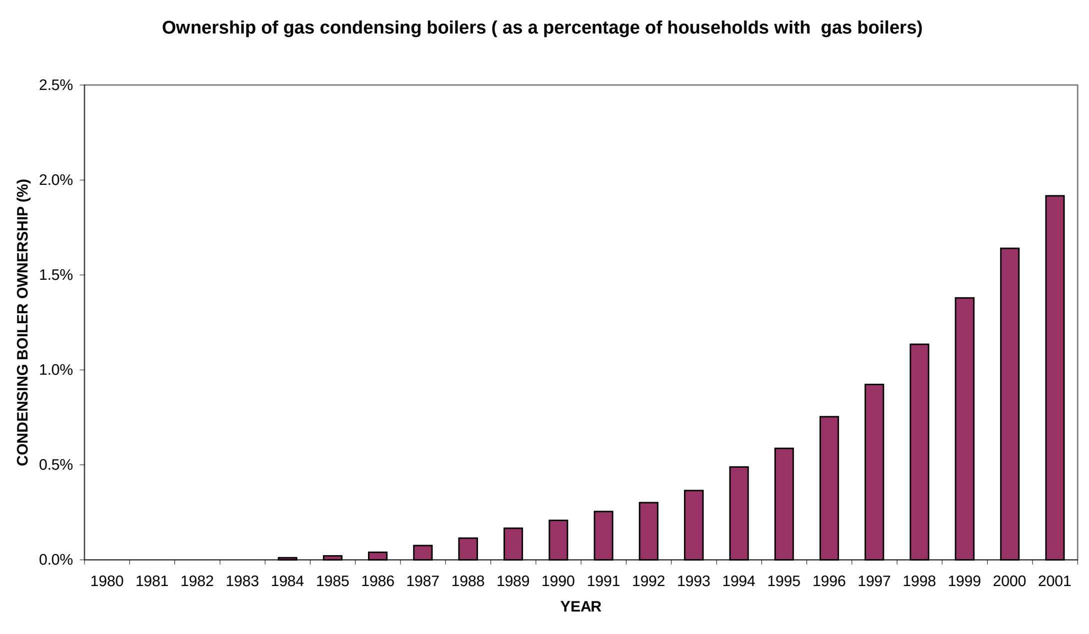


Figure 23. Condensing boiler ownership

The growth in gas central heating illustrated in Figure 21 has led to improved heating efficiencies within the stock, as will be seen in Figure 24. Initially, this was due to the replacement of inefficient forms of heating, such as open coal fires, with modern conventional gas boiler systems. In the 1980s, however, a new type of gas boiler, known as a *condensing boiler*, was introduced having a significantly higher efficiency than a conventional gas boiler. The introduction of these boilers, coupled with legislation that sets minimum levels for boiler efficiencies, promises to continue and probably accelerate the trend towards ever increasing average heating efficiencies.

Figure 23 shows how condensing boilers have begun to establish themselves within homes using gas central heating. In 2001, 1.9% of dwellings with gas central heating had condensing boilers and the ownership levels now look to be growing quite rapidly, perhaps helped by the introduction of grants for such boilers in 1996/97 [2].

Indeed, recent figures indicate that sales of condensing boilers are increasing quickly, representing about 13% of gas boiler sales in the final months of 2002, as compared with about 7% of sales during 2001. This trend should ensure that average heating efficiencies continue to increase in the future.

Table 23. Percentage of gas boilers that are condensing - UK figures

Year	Total	Condensing	Non-condensing	% condensing boilers
1980	6309	0	6309	0.00%
1981*	6907	0	6907	0.00%
1982*	7505	0	7505	0.00%
1983*	8103	0	8103	0.00%
1984*	8702	1	8701	0.01%
1985	9302	2	9300	0.02%
1986*	9961	4	9957	0.04%
1987*	10623	8	10615	0.07%
1988*	11285	13	11272	0.11%
1989*	11949	20	11929	0.17%
1990	12613	26	12587	0.21%
1991	13134	33	13101	0.25%
1992	13631	41	13590	0.30%
1993	14148	52	14097	0.36%
1994	14688	72	14616	0.49%
1995	15147	89	15058	0.59%
1996	15601	118	15483	0.75%
1997	16055	148	15906	0.92%
1998	16551	188	16363	1.13%
1999	17087	236	16851	1.38%
2000	17657	290	17367	1.64%
2001+	17842	342	17500	1.92%

Source: Boiler model developed for the Market Transformation Programme

Figures for 1981 to 1984 and 1986 to 1989 are interpolated. The 2001 figures are based on the projections of the boiler model.

Heating appliances and efficiencies

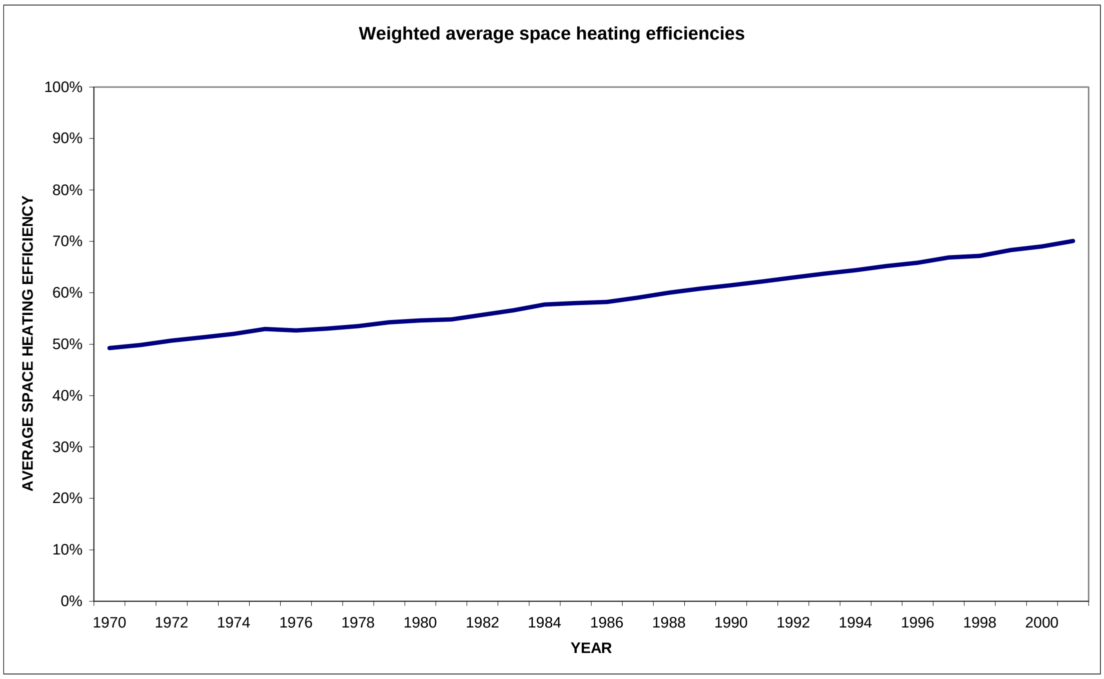


Figure 24. Weighted average space heating efficiencies

In estimating the average level of heating appliance efficiency, more confidence can be placed in the improvement over the years than in absolute values. In the past, average efficiencies have been influenced more by changes from one fuel to another (i.e. largely from solid fuel to gas) and from individual fires to central heating, rather than through improvements to the efficiency of particular appliances. Now that over 90% of dwellings have central heating efficiency improvements will come mainly from increased efficiency of boilers, in particular, the increasing numbers of condensing boilers, illustrated in Figure 23.

DEFRA's Market Transformation Programme aims to bring forward products, systems and services which do less harm to the environment, using less energy, water and other resources. As part of this programme work has been carried out looking at the efficiencies of boilers and of the current boiler stock . The resulting boiler model has provided information on efficiencies that has been used to improve on the values used in BREHOMES, and hence to improve on the values used for previous Domestic Energy Fact Files.

The figures in Table 24, illustrated in Figure 24, are thus improved estimates of efficiencies. These figures are undoubtedly more robust than previous estimates, although in practice they do not actually differ from those previous estimates by very much.

Table 24. Weighted average space heating efficiencies - GB figures

Year	Central heating efficiency	Non-central heating efficiency	Average efficiency
1970	59%	46%	49%
1971	60%	46%	50%
1972	60%	46%	51%
1973	61%	46%	51%
1974	61%	46%	52%
1975	61%	47%	53%
1976	61%	46%	53%
1977	60%	46%	53%
1978	61%	47%	54%
1979	60%	48%	54%
1980	60%	48%	55%
1981	60%	49%	55%
1982	60%	50%	56%
1983	60%	51%	57%
1984	62%	51%	58%
1985	62%	51%	58%
1986	62%	51%	58%
1987	62%	51%	59%
1988	63%	52%	60%
1989	64%	51%	61%
1990	65%	52%	61%
1991	65%	51%	62%
1992	66%	52%	63%
1993	66%	52%	64%
1994	67%	52%	64%
1995	68%	53%	65%
1996	68%	52%	66%
1997	69%	53%	67%
1998	70%	53%	67%
1999	71%	54%	68%
2000	71%	55%	69%
2001	72%	58%	70%

Source: BREHOMES

These are average efficiencies, weighted in accordance with the number of appliances of different types. Variations between years reflect changes between fuels and between appliances.

Energy consumption by end use

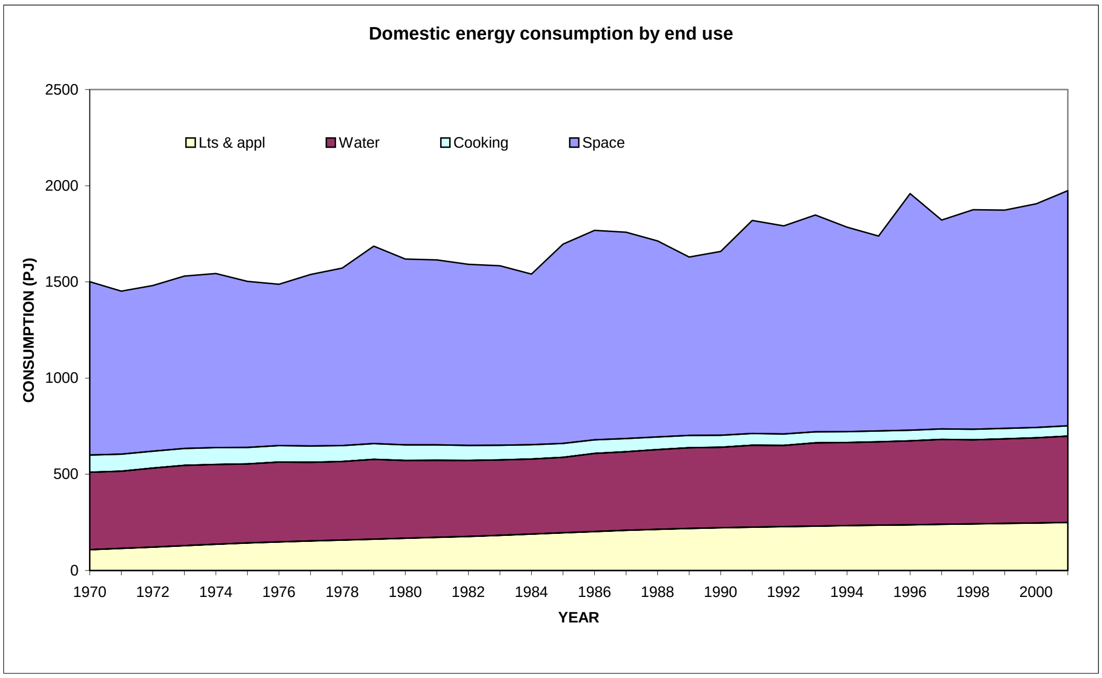


Figure 25. Domestic energy consumption by end use

The figures for the breakdown of domestic energy consumption by end use shown in Table 25 are a little more tentative than most of the others in this report. It is beyond the scope of this report to give exact details of how the estimates have been obtained. The following is a brief summary of the methodology.

The figures in Table 25 show total delivered energy for each end use. The figures were actually calculated fuel by fuel and then totalled. For electricity, the breakdown between space and water heating broadly follows estimates produced by the former Electricity Council[8] and that between lights and appliances and cooking is based on the most recent estimates made by the Environmental Change Institute (ECI) of Oxford University for the DECADE project [9]. The ECI figures for gas cooking have also been adopted for this edition of the Domestic Energy Fact File. It is interesting to note that the consumption for lights and appliances has risen considerably over the years – although this end use still represents a relatively small part of the total delivered energy.

The electricity estimates for cooking have been used to derive figures for the cooking consumptions for solid fuel and oil. Knowing the number of households using these fuels for cooking together with the efficiencies relative to electric cookers, it is possible to deduce the total delivered energy for cooking. In fact there are very few households using these fuels for cooking so the calculated amounts are small and hence not very critical in determining an overall cooking consumption.

Water heating consumption by fuels other than electricity has been based on an estimate of the average volume of hot water used per person together with figures on the proportions of households heating water using different fuels. The volume of hot water used per person has been assumed to rise in proportion to household incomes. The overall efficiencies of water heating appliances include an element to adjust for the loss from the hot water tank which reduces according to the level of the tank insulation.

Having estimated the delivered energy by fuel for each of the above mentioned end uses, and knowing the total domestic energy consumption by fuel, the space heating energy use is obtained as the difference.

Energy consumption by end use

Table 25. Domestic energy consumption by end use (PJ and GJ) - GB figures

Year	Space heating (PJ)	Water heating (PJ)	Lights & appliances (PJ)	Cooking (PJ)	All energy (PJ)	All energy per household (GJ)	Space heating per household (GJ)
1970	901.4	402.2	108.4	89.5	1501.5	83.5	50.1
1971	846.9	401.4	114.7	89.0	1452.0	79.7	46.5
1972	861.0	410.4	121.6	88.4	1481.3	80.4	46.7
1973	896.3	417.3	129.3	87.8	1530.6	82.3	48.2
1974	904.9	414.8	136.8	87.0	1543.4	82.2	48.2
1975	862.6	410.7	143.2	86.2	1502.7	79.1	45.4
1976	839.3	414.6	149.0	85.3	1488.2	77.5	43.7
1977	891.6	408.7	153.9	84.4	1538.5	79.1	45.8
1978	922.6	407.4	158.6	83.3	1572.0	80.0	47.0
1979	1026.0	414.5	163.2	82.2	1685.9	85.0	51.7
1980	966.0	404.4	167.9	80.9	1619.3	80.9	48.3
1981	961.5	400.3	172.8	79.6	1614.2	80.0	47.7
1982	941.5	394.7	177.3	78.1	1591.6	78.3	46.3
1983	932.0	392.5	182.7	76.4	1583.6	77.2	45.4
1984	886.5	390.6	189.1	74.5	1540.6	74.2	42.7
1985	1036.2	391.7	195.9	72.6	1696.3	80.7	49.3
1986	1087.8	406.1	202.9	70.5	1767.3	83.2	51.2
1987	1072.9	408.1	209.4	68.4	1758.8	81.9	49.9
1988	1018.5	414.1	214.1	66.2	1712.9	78.9	46.9
1989	926.9	419.4	218.7	64.2	1629.1	74.3	42.3
1990	955.2	418.3	222.2	62.3	1658.1	74.9	43.1
1991	1107.4	426.1	225.2	60.7	1819.4	81.3	49.5
1992	1082.5	421.7	228.1	59.3	1791.6	79.3	47.9
1993	1126.4	432.4	230.7	58.1	1847.7	81.0	49.4
1994	1062.6	431.6	233.3	57.2	1784.6	77.3	46.0
1995	1012.9	433.6	235.5	56.4	1738.4	74.6	43.4
1996	1230.0	436.1	237.7	55.8	1959.5	83.4	52.4
1997	1085.0	440.9	240.0	55.3	1821.2	76.9	45.8
1998	1141.2	436.9	242.5	54.8	1875.5	78.5	47.8
1999	1134.4	439.4	244.8	54.4	1873.0	77.7	47.0
2000	1162.8	442.5	247.3	54.1	1906.6	78.6	47.9
2001	1222.1	448.8	249.6	53.7	1974.3	80.8	50.0

Source: BREHOMES

In all the years, space heating consumption is estimated to be around 60% of the total consumption. This proportion is entirely in line with what would be expected for an average dwelling. The amount of heat actually provided by the space heating system is always less than the requirement of a dwelling since there are sources of free heat to be gained from appliances, lighting, cooking etc. This means that should there be a slightly incorrect allocation between space heating and other end uses, it will not have as great an effect on calculated internal temperatures, or on estimates of potential energy savings through insulation, as might be expected.

Standards of comfort

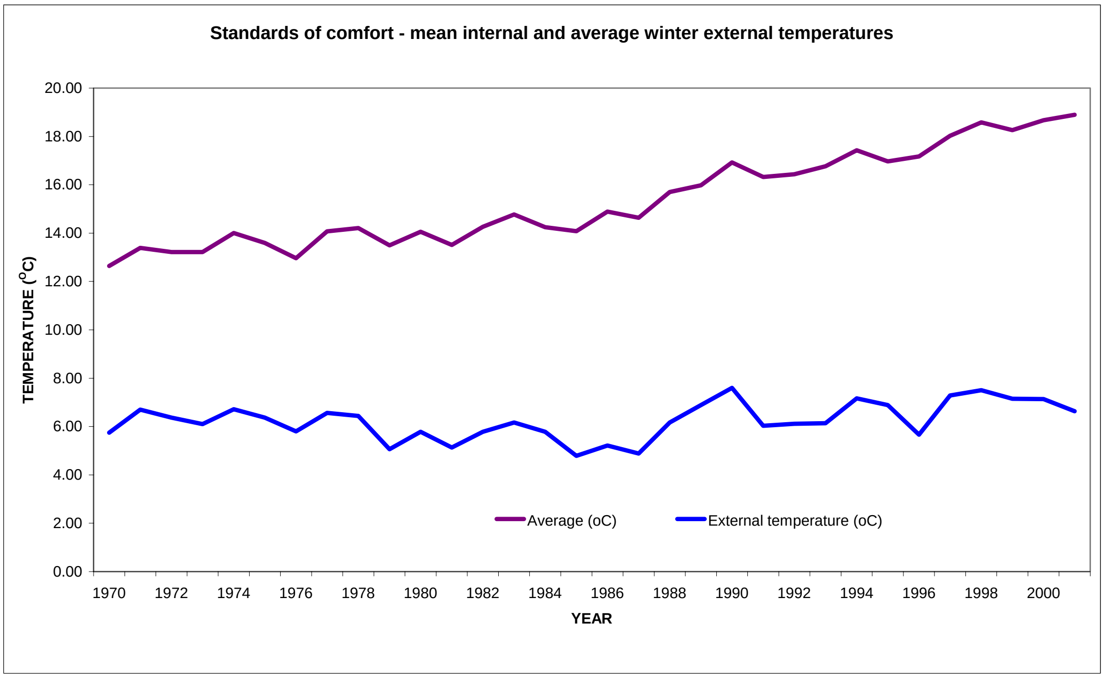


Figure 26. Standards of comfort – mean internal and average winter external temperatures

The average household used 83.5 GJ of energy in 1970 and 80.8 GJ in 2001. The corresponding space heating figures were 50.1 GJ in 1970 and 50.0 GJ in 2001. The space heating energy consumption per household, therefore, appears to have remained stable throughout this period despite the large growth in central heating ownership from 31% in 1970 to 90% in 2001.

The effect of the increase in central heating ownership must have been to raise average dwelling temperatures. Broad estimates can be made of the magnitude of the rise. By running heat balance equations for all the years in question it is possible to deduce a 24 hour average internal temperature during the six winter months. The results of these calculations are illustrated in Figure 26 above and the values are given in Table 26.

The absolute values of these temperatures cannot be quoted with as much confidence as estimates of the extent of the rise. However the general level of temperatures in houses has been suggested by a number of surveys. One such survey, carried out in February and March 1978 [10] gave the average daytime temperature of occupied dwellings as approximately 17°C and 14°C for centrally heated and non-centrally heated households respectively. For comparison, the 1991 English House Condition Survey [11] recorded spot temperatures of 18.6°C and 16.6°C respectively in hallways of centrally heated and non-centrally heated homes. The values from the 1996 survey were 18.1°C and 16.8°C. The 24 hour averages would be slightly lower.

The temperature rise over the period for both centrally heated and non-centrally heated dwellings is estimated to be 4.75°C but the average temperature has increased by 6.2°C because of the increasing numbers of centrally heated houses.

It would be expected that the average temperature would stabilise as more households move towards their desired comfort levels. For most people, a living room temperature during occupied periods of 21°C would be regarded as comfortable. A temperature perhaps 2°C

Standards of comfort

Table 26. Standards of comfort mean internal and average winter external temperatures - GB figures

Year	Dwellings with central heating (%)	Centrally heated homes (^{o}C)	Non-centrally heated homes (^{o}C)	Average (^{o}C)	External temperature (^{o}C)	Total households (1,000s)
1970	31.3%	14.36	11.86	12.64	5.8	17987
1971	34.4%	15.03	12.53	13.39	6.7	18221
1972	37.3%	14.78	12.28	13.22	6.4	18426
1973	41.2%	14.69	12.19	13.22	6.1	18603
1974	45.9%	15.36	12.86	14.00	6.7	18783
1975	49.1%	14.87	12.37	13.59	6.4	18988
1976	51.5%	14.18	11.68	12.96	5.8	19215
1977	53.7%	15.23	12.73	14.08	6.6	19450
1978	54.1%	15.35	12.85	14.21	6.4	19650
1979	56.4%	14.58	12.08	13.50	5.1	19827
1980	57.6%	15.12	12.62	14.06	5.8	20010
1981	58.7%	14.54	12.04	13.51	5.1	20177
1982	60.9%	15.24	12.74	14.26	5.8	20327
1983	65.5%	15.63	13.13	14.77	6.2	20525
1984	67.5%	15.06	12.56	14.25	5.8	20769
1985	70.3%	14.82	12.32	14.08	4.8	21017
1986	72.2%	15.58	13.08	14.89	5.2	21254
1987	74.4%	15.28	12.78	14.64	4.9	21485
1988	75.5%	16.32	13.82	15.71	6.2	21710
1989	77.9%	16.53	14.03	15.98	6.9	21927
1990	79.4%	17.44	14.94	16.92	7.6	22140
1991	81.8%	16.78	14.28	16.32	6.0	22392
1992	82.9%	16.86	14.36	16.43	6.1	22595
1993	84.3%	17.16	14.66	16.77	6.1	22822
1994	85.7%	17.79	15.29	17.43	7.2	23076
1995	87.0%	17.29	14.79	16.97	6.9	23315
1996	87.0%	17.50	15.00	17.18	5.7	23492
1997	87.7%	18.34	15.84	18.03	7.3	23694
1998	89.1%	18.85	16.35	18.58	7.5	23896
1999	89.2%	18.53	16.03	18.26	7.2	24120
2000	89.1%	18.95	16.45	18.67	7.1	24271
2001	90.2%	19.14	16.64	18.89	6.6	24422

Source: BREHOMES

below this would generally be considered adequate elsewhere in the dwelling so that the overall comfort level might be around 19-20^{o}C. As insulation improves and central heating ownership increases it is likely that this temperature will become the optimum throughout a dwelling for 24 hours per day and could, therefore, be taken to be the ultimate comfort level beyond which most people would not wish to go.

The effect of energy efficiency improvements

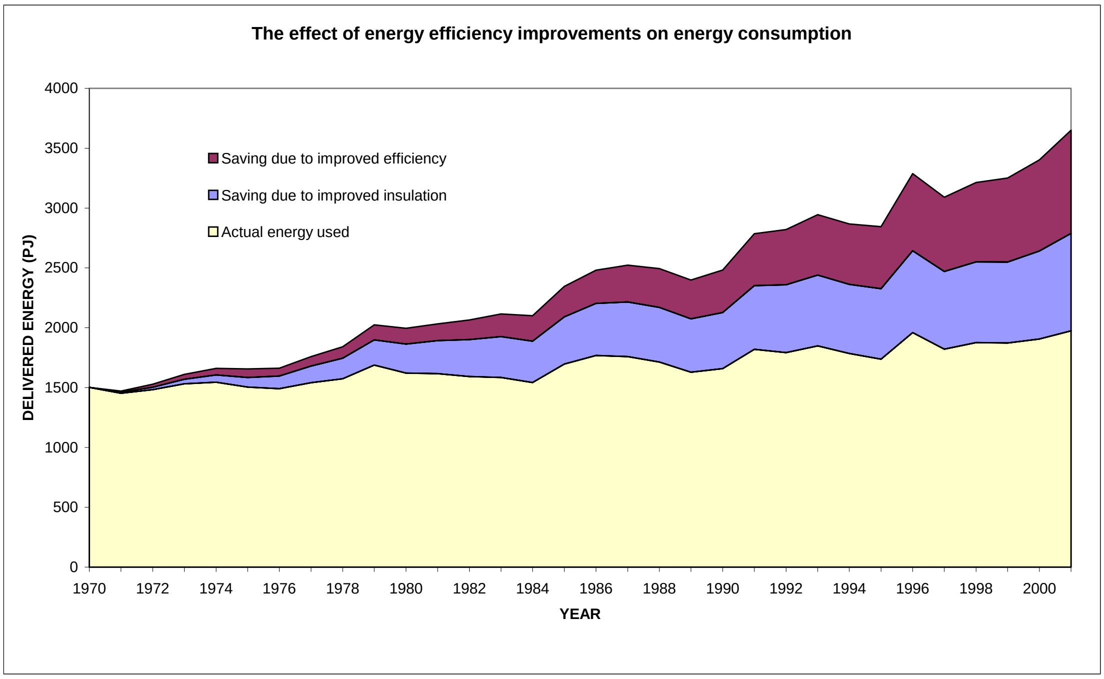


Figure 27. The effect of energy efficiency improvements on energy consumption

Table 26 suggests that an average 24 hour temperature of 12.6°C was achieved in 1970 when the GB domestic energy consumption was 1501PJ and that an average temperature of 18.9°C was achieved in 2001 when consumption was 1974PJ.

If insulation and efficiency measures had remained as they were in 1970 how much more energy would now be required to maintain the average 2001 internal temperatures?
In Table 26 internal temperatures were calculated from a given consumption of energy. In Figure 27 the calculation is reversed. Energy consumption is calculated from a given level of temperature. The figure shows the consumptions calculated for each year using the temperatures from Table 26 but assuming that the insulation and efficiency levels are those for 1970. The values are given in Table 27.

The 2001 consumption is calculated to be 3649.3PJ which is 1675.0PJ more than the actual energy used. Of this difference 814.1PJ would be ascribed to improvements in insulation and 861.0PJ to improved heating efficiency. Thus, it may be concluded that energy efficiency measures have resulted in a saving of 46% relative to what the consumption would have been without those measures.

Readers should be aware, however, that there are a number of conceptual difficulties in the definition of savings achieved by energy efficiency measures. For example, it has been assumed that 2001 households would maintain 2001 temperatures despite having 1970 insulation measures. In reality, the temperature would probably be allowed to drop from the 2001 level by choice and for reasons of building physics (the 24 hour temperature in a dwelling for any given intermittent heating pattern, depends on the insulation standard – it is lower in a poorly insulated dwelling than in a well insulated dwelling). The problem is of course, that there is no way of knowing by how much the temperature would have been allowed to fall in practice.

The calculated figure is therefore hypothetical but it does give a good indication of the quantity of energy that has been saved by energy efficiency measures. The definition used is actually a measure of two things - the energy saved and the energy value of improved comfort standards.

Table 27. The effect of energy efficiency improvements on energy consumption (PJ) - GB figures

Year	Total households (1,000s)	Actual energy used	Energy use if 1970 insulation standard	Energy use if 1970 insulation & efficiency standard	Saving due to improved insulation	Saving due to improved efficiency	Total saving
1970	17987	1501.0	1501.0	1501.0	0.0	0.0	0.0
1971	18221	1453.2	1461.2	1471.6	8.0	10.4	18.4
1972	18426	1482.3	1502.6	1528.6	20.3	26.0	46.3
1973	18603	1532.1	1570.0	1609.7	37.9	39.7	77.6
1974	18783	1545.5	1605.6	1659.9	60.1	54.4	114.5
1975	18988	1504.8	1585.1	1656.3	80.3	71.2	151.4
1976	19215	1490.3	1596.0	1662.0	105.6	66.1	171.7
1977	19450	1540.4	1679.7	1758.5	139.2	78.9	218.1
1978	19650	1573.7	1745.8	1841.2	172.1	95.4	267.5
1979	19827	1687.7	1898.7	2024.3	211.0	125.7	336.6
1980	20010	1620.8	1862.9	1994.8	242.1	131.9	373.9
1981	20177	1615.7	1892.0	2032.5	276.3	140.6	416.9
1982	20327	1592.7	1901.5	2065.6	308.8	164.0	472.9
1983	20525	1584.6	1925.0	2115.0	340.4	190.0	530.4
1984	20769	1541.6	1888.0	2100.6	346.5	212.6	559.1
1985	21017	1697.1	2090.5	2345.2	393.4	254.7	648.1
1986	21254	1768.0	2202.9	2480.0	435.0	277.0	712.0
1987	21485	1759.0	2216.1	2523.3	457.1	307.2	764.3
1988	21710	1712.9	2169.8	2494.7	456.8	324.9	781.7
1989	21927	1629.1	2074.6	2398.3	445.5	323.7	769.1
1990	22140	1658.1	2127.2	2482.8	469.1	355.6	824.7
1991	22392	1819.4	2351.9	2785.3	532.5	433.4	965.9
1992	22595	1791.6	2359.4	2820.1	567.8	460.7	1028.5
1993	22822	1847.7	2439.7	2944.5	592.0	504.8	1096.8
1994	23076	1784.6	2362.8	2867.2	578.2	504.4	1082.6
1995	23315	1738.4	2325.5	2844.2	587.1	518.6	1105.7
1996	23492	1959.5	2642.6	3287.0	683.2	644.4	1327.6
1997	23694	1821.2	2470.1	3090.4	648.9	620.3	1269.2
1998	23896	1875.5	2551.1	3213.3	675.7	662.2	1337.8
1999	24120	1873.0	2549.1	3250.4	676.1	701.3	1377.4
2000	24271	1906.6	2641.2	3403.2	734.6	761.9	1496.6
2001	24422	1974.3	2788.4	3649.3	814.1	861.0	1675.0

Source: BREHOMES

Comparison of SAP ratings

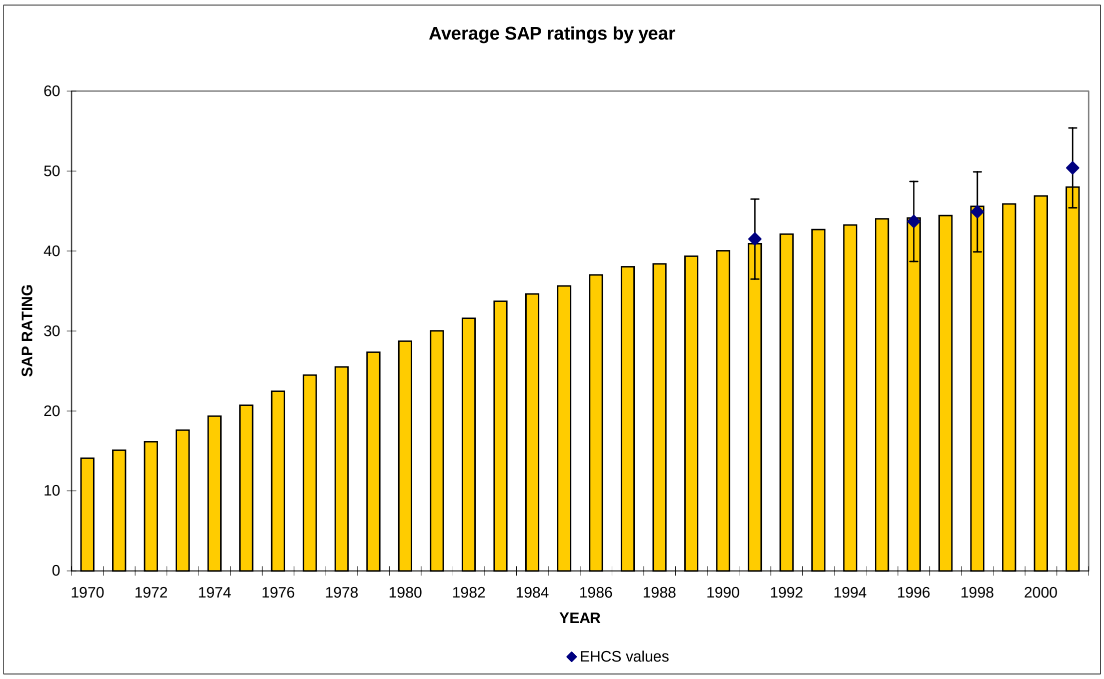


Figure 28. Average SAP ratings by year

An alternative way of illustrating the overall effect of energy efficiency improvements is by considering the energy rating of the average dwelling within the stock. The energy rating that is used for this purpose is the Government's Standard Assessment Procedure [7], commonly referred to as SAP . This is a rating on a scale 1 to 120 where 1 indicates an extremely energy inefficient dwelling and 120 indicates an extremely energy efficient dwelling (the previous scale for SAP had a maximum of 100, but the scale has been increased to account for further possible improvements in the housing stock). It is determined from an estimate of the space and water heating costs for the dwelling. This is normalised for floor area and incorporates a number of standardised assumptions about occupancy, heating patterns, internal temperatures, climatic factors etc.

The specific heat loss of a dwelling, the type of heating system and the fuel that it uses, are key factors in determining the SAP rating. Changes in these factors have already been discussed in this report and this information can be used to calculate SAP ratings for all years from 1970 to 2001. The resulting SAP ratings are illustrated in Figure 28. This shows that the average SAP rating in 1970 was about 14 and by 2001 this had increased to about 48. Bearing in mind the uncertainty in SAP ratings of about +/-5 points, the figures obtained are in excellent agreement with estimates that have emerged from the English House Condition Survey [11,12, 13, 14], as Figure 28 shows. Also, note that the SAP ratings presented here are nominal values because much of the information required for a full SAP calculation is not available.

It is questionable whether it is actually meaningful to present a SAP rating for years long before the rating was defined. Several of the standardised assumptions that form an integral part of SAP would not strictly apply to these years. Nonetheless, it is clear from the calculated figures that the energy rating of the average dwelling has improved substantially and that, in addition to the obvious effect of the improvement in heat loss, this is largely due to the increasing ownership of central heating, the figures for which are shown in Table 28.

Comparison of SAP ratings

Table 28. Average SAP ratings by year - GB figures (EHCS figures for England)

Year	Total homes with central heating (1,000s)	Total homes without central heating (1,000s)	Total households (1,000s)	SAP rating of average house	SAP rating of average house from EHCS
1970	5628	12359	17987	14.1	
1971	6271	11950	18221	15.1	
1972	6867	11559	18426	16.2	
1973	7669	10934	18603	17.6	
1974	8628	10155	18783	19.4	
1975	9315	9673	18988	20.7	
1976	9888	9327	19215	22.5	
1977	10454	8996	19450	24.5	
1978	10633	9017	19650	25.5	
1979	11192	8635	19827	27.3	
1980	11517	8493	20010	28.7	
1981	11851	8326	20177	30.0	
1982	12374	7953	20327	31.6	
1983	13443	7082	20525	33.7	
1984	14029	6740	20769	34.6	
1985	14778	6239	21017	35.6	
1986	15337	5917	21254	37.0	
1987	15981	5504	21485	38.0	
1988	16396	5314	21710	38.4	
1989	17089	4838	21927	39.4	
1990	17573	4567	22140	40.0	
1991	18309	4083	22392	40.9	41.5
1992	18727	3868	22595	42.1	
1993	19229	3593	22822	42.7	
1994	19782	3294	23076	43.2	
1995	20274	3041	23315	44.0	
1996	20438	3054	23492	44.1	43.7
1997	20791	2903	23694	44.4	
1998	21294	2602	23896	45.6	44.9
1999	21517	2603	24120	45.9	
2000	21625	2646	24271	46.9	
2001	22030	2392	24422	48.0	50.4

Source: BREHOMES
English House Condition Survey

8 How domestic sector energy consumption is determined

Main trends

It should be clear to the reader by now that there are many interacting factors which determine the energy consumption of the housing stock. For space heating these can be summarised as follows:

- There is a natural variation due to changes in the external temperature.
- There is a trend towards lower heat losses due to insulation, which tends to reduce energy consumption.
- There is a trend towards improved comfort linked to the growth of central heating, which tends to increase consumption
- There is a trend towards improved space heating efficiencies due to changes of fuel, more central heating and better heating appliance efficiencies, which tends to reduce energy consumption

In addition, there is a continuing growth in the size of the housing stock which tends to increase energy consumption across all end uses.

The improvement in comfort standards is just one aspect of an improvement in the general level of service required by households. Another clear example is the increasing electricity use of lights and appliances (see Figure 25). Although there may be several individual level of service effects, they are all ultimately related to a general improvement in our standard of living, so it is convenient to consider them all together.

Predicting housing stock energy use

The above considerations suggest that it should be possible to derive an equation which describes the changes in the energy consumption of the housing stock since 1970. Following the discussion above, it is clear that suitable variables for such an equation are a term increasing each year to allow for increased levels of service demanded by householders, the external temperature, the improvement in the average dwelling heat loss, the improvement in the average heating efficiency and the number of households.

Using regression techniques, together with the figures in several tables from the last section, the following equation has been derived:

$$Q = N\,[97.81 + (2.12 \times \{\text{year-1970}\}) - (3.30 \times Te) - (0.26 \times \Delta H) - (1.49 \times \Delta E\%)\,]$$

Where

- Q is the housing stock consumption (PJ)
- N is the number of households (millions)
- Te is the winter external temperature (^{o}C)
- ΔH is the improvement in the average dwelling heat loss relative to 1970 (for 2001 this is 376.0 – 259.1=116.9 W/^{o}C. See Table 19)
- $\Delta E\%$ is the improvement in the average heating efficiency relative to 1970 (for 2001 this is 70%-49%=21%. See Table 24)

The predictions of this equation are in good agreement with actual consumptions, as shown in Figure 29 and Table 29.

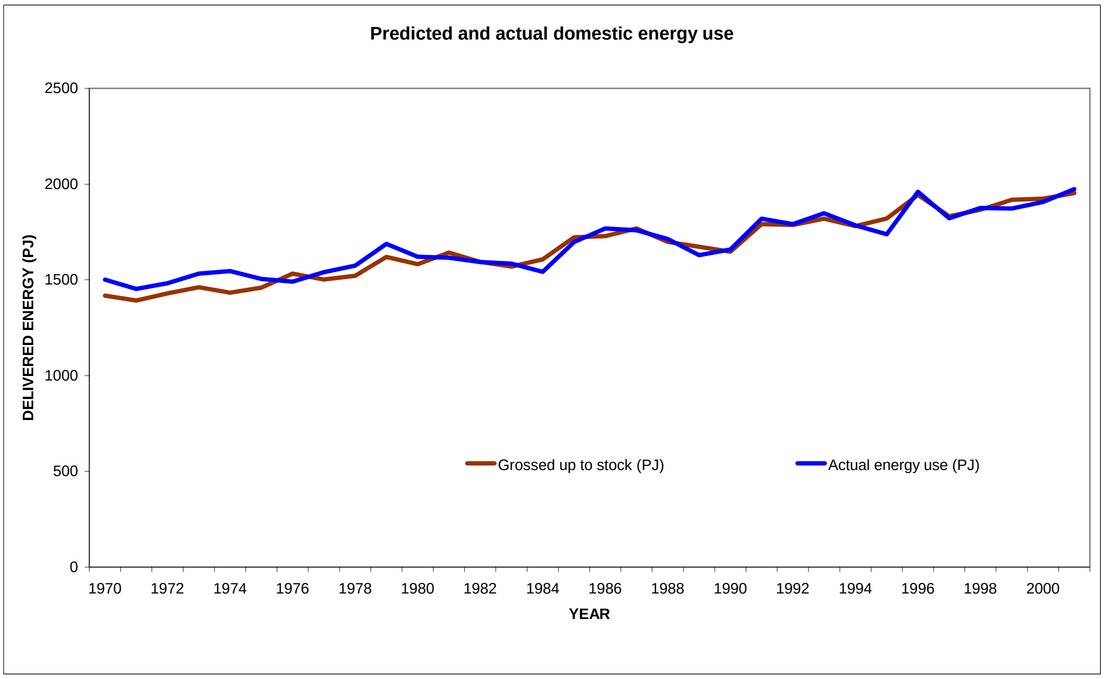


Figure 29. Predicted and actual domestic energy use

Figure 29 shows the predicted energy consumption for the housing stock and the actual energy consumption. It can be seen that there is close agreement between the two. Table 29 shows what is happening in greater detail. It illustrates how the changes in each variable have combined to produce the overall housing stock energy consumption.

- Year - the first column shows an increase of 2.12 GJ per year as a result of increasing levels of service standards of comfort.
- Te – in the next column the variations to be expected from fluctuating external temperature are introduced. The temperature variation alters the consumption by 3.30GJ per ^{o}C change.
- ΔH – in the third column, the effect of improving heat loss is added in. For each 1 W/^{o}C improvement the consumption falls by 0.26 GJ.
- ΔE – in the fourth column the effect of improving heating efficiency is introduced. For each percentage point improvement in the efficiency the consumption falls by 1.49GJ.
- N – in the fifth column, the figure in the fourth column (which is an estimate of the average dwelling consumption) is multiplied by the number of households.

It can be seen that the “grossed up to stock” estimates are in quite good agreement with the actual housing stock energy consumption figures shown in the final column. In fact, the difference between the predictions and the actual consumptions has a standard deviation of only 45PJ i.e. the predictions are generally within about 2.2% to 3% of the actual consumptions.

The general level of agreement between the predictions and actual consumption figures can also be gauged from Figure 29. It is clear that the equation which has been derived describes the observed changes to the housing stock energy consumption quite well.

In principle this equation could also be used to predict future housing stock consumption, given estimates of the relevant variables for the years under consideration. Short term projections would probably prove to be reasonably reliable (timescales of less than 10 years). However, longer term predictions would be expected to be less robust. As central heating ownership approaches saturation, so other level of service effects would become more

Table 29. How domestic energy consumption is determined (PJ/GJ) - GB figures

	Year	Te	ΔH	ΔE	N	Q
Year	Corrected for year (GJ)	Corrected for temps (GJ)	Effect of improved insulation (GJ)	Effect of improved efficiency (GJ)	Grossed up to stock (PJ)	Actual energy use (PJ)
1970	77.19	78.82	78.82	78.82	1417.7	1501.0
1971	79.31	77.80	77.28	76.38	1391.8	1453.2
1972	81.44	81.03	79.71	77.55	1428.9	1482.3
1973	83.56	84.03	81.66	78.54	1461.1	1532.1
1974	85.69	84.12	80.43	76.30	1433.2	1545.5
1975	87.81	87.40	82.39	76.86	1459.5	1504.8
1976	89.94	91.40	84.86	79.74	1532.2	1490.3
1977	92.06	90.99	82.82	77.21	1501.8	1540.4
1978	94.18	93.55	83.81	77.42	1521.3	1573.7
1979	96.31	100.19	89.13	81.68	1619.5	1687.7
1980	98.43	99.95	87.04	79.04	1581.5	1620.8
1981	100.56	104.22	89.73	81.41	1642.5	1615.7
1982	102.68	104.20	88.05	78.43	1594.2	1592.7
1983	104.80	105.05	87.40	76.46	1569.3	1584.6
1984	106.93	108.44	90.03	77.39	1607.3	1541.6
1985	109.05	113.87	94.98	81.92	1721.8	1697.1
1986	111.18	114.56	94.65	81.31	1728.2	1768.0
1987	113.30	117.79	96.95	82.31	1768.4	1759.0
1988	115.43	115.67	94.26	78.21	1697.9	1712.9
1989	117.55	115.43	93.46	76.28	1672.6	1629.1
1990	119.67	115.19	92.59	74.39	1647.0	1658.1
1991	121.80	122.49	99.25	79.98	1790.9	1819.4
1992	123.92	124.34	99.52	79.06	1786.3	1791.6
1993	126.05	126.41	101.27	79.74	1819.8	1847.7
1994	128.17	125.12	99.70	77.16	1780.6	1784.6
1995	130.29	128.18	101.83	78.07	1820.3	1738.4
1996	132.42	134.32	107.44	82.75	1943.9	1959.5
1997	134.54	131.10	103.55	77.33	1832.1	1821.2
1998	136.67	132.51	104.80	78.08	1865.9	1875.5
1999	138.79	135.79	107.92	79.53	1918.2	1873.0
2000	140.92	137.97	108.70	79.27	1923.9	1906.6
2001	143.04	141.75	110.95	79.96	1952.7	1974.3

dominant. Notwithstanding this, it would be expected that many other levels of service would also have saturated or would be close to saturation at about the same time as central heating. The fairly steady historical growth due to improving levels of service, which is illustrated in the first column of Table 29 would not be expected to continue indefinitely.

The equation can also be used to investigate the historical importance of the individual factors and how they have contributed to the changes to energy use and carbon emissions. A separate paper on this topic, focusing on decomposing the historical carbon emission changes illustrated in Figure 31 has been prepared, which the interested reader may wish to seek out [15].

9 Types of fuel, carbon emissions and primary energy use

Main trends

Up to this point, energy has been treated as though it were a single homogenous entity. Apart from mention of ownership and efficiency of different heating systems, the different forms of delivered energy (ie different fuels including electricity) have not been discussed.

Delivered fuel type is an important consideration because each fuel has different primary sources associated with it, and different losses in conversion, transmission and distribution. This also means that the environmental implications of consumption of each delivered fuel are different.

In this section the delivered fuels used by the housing stock, and the changes to these over the past thirty years are examined. The delivered fuel consumptions are translated into both carbon emissions and primary energy consumptions. Finally, a simplified energy balance for the housing stock is presented, which illustrates the relationships between primary energy and delivered energy and how the delivered energy for space heating and other uses, together with natural gains, meets the useful heat requirement of the housing stock.

Domestic consumption by fuel

While overall delivered energy consumption has remained relatively stable, the proportion of different fuels used for space heating has shifted steadily towards natural gas.

Carbon emissions

Whenever a fossil fuel is burnt to extract energy, carbon dioxide is produced. Carbon dioxide plays an important role in regulating the climate of the Earth, even though it is present in the atmosphere in only small concentrations, in that it absorbs infra-red radiation emitted from the Earth's surface, causing a warming of the lower atmosphere. This 'greenhouse effect' is responsible for maintaining temperatures near the Earth's surface which make life possible. There is now considerable concern that the unrelenting burning of fossil fuels, along with other human activities, is increasing the concentration of carbon dioxide and other greenhouse gases and disturbing the Earth's heat energy balance, thereby leading to an additional warming at the Earth's surface. Carbon dioxide is known to be the most important contributor to this additional warming because of the extremely large quantities which are emitted. Energy efficiency is now seen as one of the most promising means of substantially reducing carbon dioxide emissions whilst maintaining, or improving, the levels of service achieved.

Since 1970 the carbon dioxide emission which can be attributed to domestic energy use has fallen substantially. Table 31 shows the emissions associated with the different fuels. This is presented in terms of tonnes of carbon which is now the conventional way of expressing these emissions.

Primary consumption

Each delivered fuel has associated with it an equivalent in terms of primary energy, and this equivalence can be expressed as a primary energy ratio. This ratio indicates the size of the losses involved in conversion, transmission and distribution as well as the amount of energy used by the energy industries themselves. The primary energy ratio differs considerably between different delivered fuels. For a fuel where there are few losses the primary energy ratio is close to unity. As the size of the losses increases, so the primary energy ratio increases.

The overall domestic sector primary energy ratio has shown a substantial improvement between 1970 and 2001 mainly because of efficiency improvements to the supply of energy. Consequently, the domestic sector now makes better use of natural resources.

Domestic energy consumption by fuel

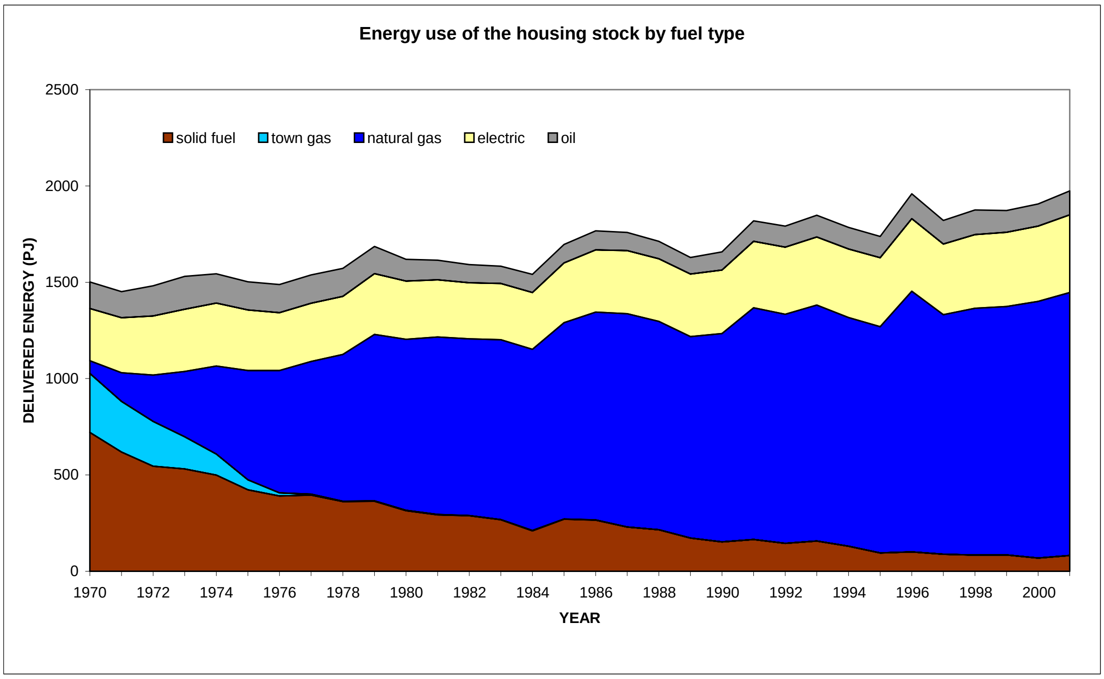


Figure 30. Energy use of the housing stock by fuel type

During the period 1970 – 2001 there has been a dramatic change in the proportions of different fuels delivered to the housing stock in GB as shown in Figure 30. This is in marked contrast to the relative stability in the total delivered energy use of the housing stock.

The main feature of the changes is the rapid penetration of natural gas. Natural gas supplied 4% of the total energy delivered to the housing stock in 1970. By 1996 the proportion had risen to just over 69% and has remained at that level for the six years up to and including 2001. Town gas has completely disappeared, whereas in 1970 it had supplied over 20% of the total housing stock demand. Similarly solid fuel use has declined from 48% of the total in 1970 to 4% in 2001 and oil from 9% to 6%. Electricity, on the other hand has remained an almost constant proportion of the total – 18% in 1970 and 20% in 2001.

Although the proportion of delivered energy represented by electricity has remained roughly constant, in absolute terms electricity use has grown by 49% over this period. Electricity use for space heating has shown a general decline so it can be deduced that the considerable increase in electricity use for lights and appliances is the driving force behind the net increase in total housing stock electricity use.

Domestic energy consumption by fuel

Table 30. Energy use of the housing stock by fuel type (PJ) - GB figures

Year	Solid	Gas (natural)	Gas (town)	Gas (total)	Electric	Oil	All fuels
1970	720.9	65.8	305.8	371.6	271.5	137.5	1501.6
1971	618.6	149.2	263.2	412.4	285.2	135.9	1452.0
1972	545.0	240.6	232.7	473.3	306.8	156.2	1481.3
1973	531.4	338.7	167.0	505.7	322.7	170.9	1530.6
1974	499.5	456.3	109.1	565.4	327.0	151.5	1543.4
1975	422.9	567.1	52.0	619.1	314.5	146.3	1502.7
1976	391.2	635.8	15.2	651.0	299.9	146.0	1488.2
1977	396.0	688.6	4.6	693.2	302.3	147.1	1538.5
1978	361.3	762.1	2.0	764.1	302.0	144.7	1572.0
1979	363.6	863.8	1.9	865.7	315.5	141.0	1685.9
1980	315.1	886.7	1.8	888.5	302.9	112.8	1619.3
1981	292.8	921.2	1.7	922.9	297.5	101.1	1614.2
1982	287.8	916.9	1.5	918.4	291.4	93.9	1591.6
1983	267.7	933.4	1.2	934.6	292.0	89.3	1583.6
1984	210.5	940.1	1.1	941.2	295.2	93.7	1540.6
1985	270.0	1019.5	1.1	1020.6	310.1	95.6	1696.3
1986	265.9	1078.7	0.8	1079.5	322.9	99.0	1767.3
1987	229.7	1106.7	0.5	1107.2	327.9	94.0	1758.8
1988	215.8	1081.6	0.0	1081.6	324.5	91.0	1712.9
1989	172.1	1046.2	0.0	1046.2	324.4	86.4	1629.1
1990	152.1	1081.7	0.0	1081.7	329.6	94.7	1658.1
1991	165.1	1202.5	0.0	1202.5	344.6	107.2	1819.4
1992	144.7	1188.6	0.0	1188.6	349.3	108.9	1791.6
1993	157.2	1224.9	0.0	1224.9	352.6	113.0	1847.7
1994	129.9	1187.2	0.0	1187.2	355.8	111.7	1784.6
1995	95.4	1173.9	0.0	1173.9	358.4	110.6	1738.4
1996	100.4	1353.3	0.0	1353.3	376.9	128.9	1959.5
1997	88.1	1244.0	0.0	1244.0	365.9	123.2	1821.2
1998	83.4	1281.3	0.0	1281.3	383.1	127.8	1875.5
1999	84.9	1289.1	0.0	1289.1	386.0	113.1	1873.0
2000	69.0	1331.6	0.0	1331.6	391.2	114.8	1906.6
2001	81.5	1364.9	0.0	1364.9	403.4	124.5	1974.3

Source: Digest of United Kingdom Energy Statistics

Carbon emissions

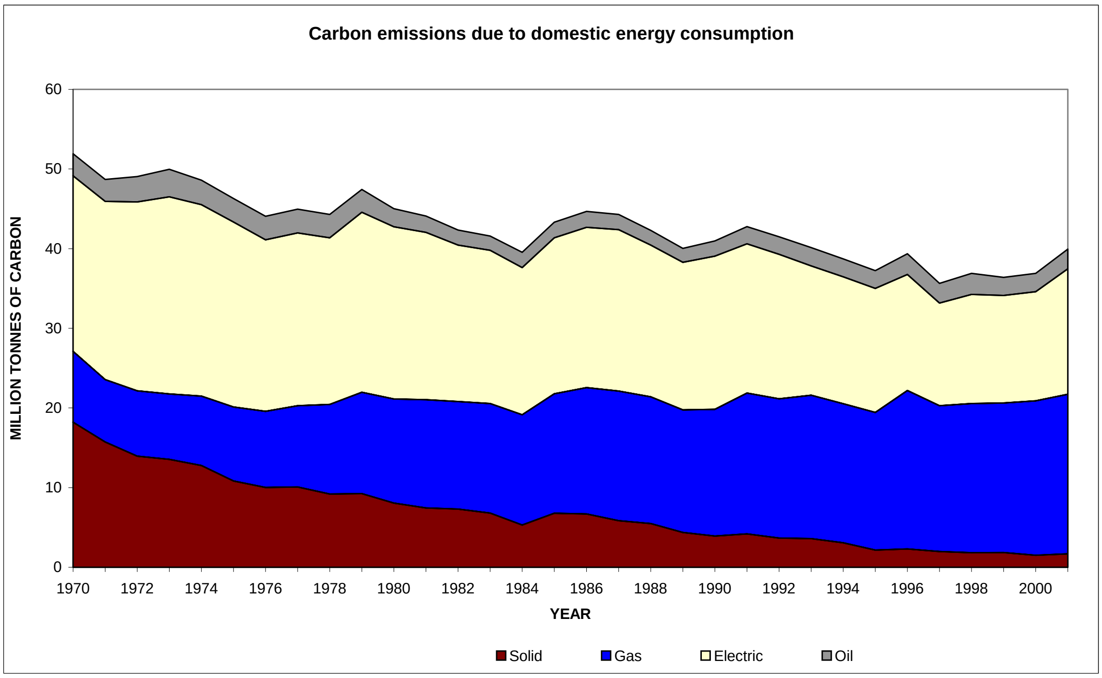


Figure 31. Carbon emissions due to domestic energy consumption

The carbon emission associated with the GB housing stock has decreased since 1970. In 1970 it was 52 million tonnes and by 1997 it had dropped to 36 million tonnes. Over the last 4 years there has been a slight increase to 40 million tonnes in 2001, most of this increase occurring in 2001.

These figures include the carbon emitted at power stations to meet the domestic electricity demand.

The reduction between 1970 and 2001 is due to a number of things:

Firstly, the energy efficiency measures discussed in this report have held domestic energy consumption down and avoided the increase in carbon emissions which would otherwise have occurred. Assuming the same fuel mix as actually applied in 2001, total domestic consumption would have been about 85% higher (see Table 27) and carbon emissions would have been about 74 million tonnes, i.e. 85% higher.

Secondly the change in fuel types used in the home has been important. Burning solid fuel produces roughly twice as much carbon per unit of delivered energy obtained as does gas, whilst oil comes between the two. Clearly, therefore, the move towards gas and away from solid fuel has had a beneficial effect.

Thirdly, although electricity use has increased, the emission associated with that electricity use has declined. This has occurred because the efficiency of generation, transmission and distribution has improved and because of an increase in the proportion of non-fossil fuel derived electricity. In the 1990s there has also been a drive towards gas turbine technology which has made electricity generation less reliant on solid fuel. However, recent changes have seen a return to a higher proportion of solid fuel and this partly accounts for the increase in carbon emissions since 1997.

A separate paper has been prepared on historical carbon emissions, focusing on decomposing these into the factors identified in the equation presented in the last section, and this provides more detail of the importance of the changes noted above [15].

Carbon emissions

Table 31. Carbon emissions due to domestic energy consumption (million tonnes) - GB figures

Year	Solid	Gas	Electric	Oil	Total	UK total
1970	18.2	8.9	22.0	2.8	51.9	53.3
1971	15.7	7.8	22.4	2.8	48.7	49.9
1972	13.9	8.2	23.7	3.2	49.0	50.3
1973	13.6	8.2	24.7	3.5	50.0	51.3
1974	12.8	8.7	24.0	3.1	48.6	50.1
1975	10.8	9.3	23.2	3.0	46.3	47.8
1976	10.0	9.6	21.5	3.0	44.1	45.5
1977	10.1	10.2	21.7	3.0	45.0	46.5
1978	9.2	11.2	20.9	2.9	44.3	45.8
1979	9.2	12.7	22.6	2.9	47.4	49.1
1980	8.1	13.1	21.6	2.3	45.0	46.6
1981	7.4	13.6	21.0	2.1	44.1	45.5
1982	7.3	13.5	19.6	1.9	42.3	43.9
1983	6.8	13.7	19.2	1.8	41.6	43.1
1984	5.3	13.8	18.5	1.9	39.5	40.9
1985	6.8	15.0	19.6	1.9	43.3	45.2
1986	6.7	15.9	20.1	2.0	44.7	46.5
1987	5.8	16.3	20.2	1.9	44.3	46.1
1988	5.5	15.9	19.1	1.8	42.3	44.0
1989	4.4	15.4	18.5	1.8	40.0	41.6
1990	3.9	15.9	19.2	1.9	41.0	42.4
1991	4.2	17.7	18.7	2.2	42.8	44.4
1992	3.7	17.5	18.1	2.2	41.5	43.0
1993	3.6	18.0	16.2	2.3	40.1	41.7
1994	3.1	17.5	15.9	2.3	38.7	40.2
1995	2.2	17.3	15.6	2.2	37.2	38.5
1996	2.3	19.9	14.6	2.6	39.4	40.7
1997	2.0	18.3	12.9	2.5	35.6	36.9
1998	1.8	18.7	13.7	2.6	36.9	38.2
1999	1.8	18.8	13.5	2.3	36.4	37.7
2000	1.5	19.4	13.7	2.3	36.9	38.2
2001	1.7	20.0	15.8	2.5	40.0	41.4

Source: BRE estimates of emission factors applied to the figures in Table 30

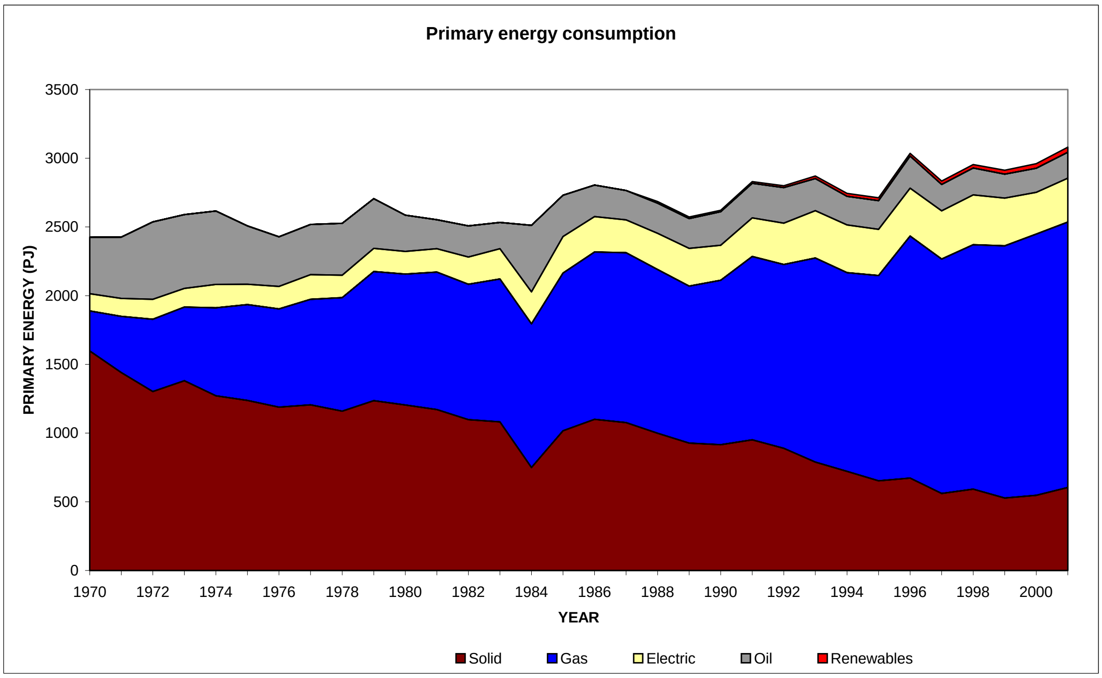


Figure 32. Primary energy consumption

As should be clear from the discussion on carbon emissions, a saving of one petajoule of one delivered fuel may not necessarily be as beneficial as a similar saving of another fuel. If there were an ideal price structure then price might be a good measure of the relative value of different forms of energy. Clearly the prices do, at least partially, reflect the values of different fuels – particularly the value of electricity relative to other fuels (see Figure 3). A better measure, however, is one which is related to the amount of primary energy consumed. This is the energy that is consumed in homes plus that required for conversion, transmission and distribution. Figure 32 shows the dramatic changes that have taken place in the proportions of different primary fuels consumed in order to meet the energy needs of the UK housing stock.

Between 1970 and 2001 the composition of primary energy fuels has changed significantly. In 1970, 66% of the total was solid fuel and 12% was gas. In 2001, 20% was solid fuel and gas had increased to 63%. There had also been a change between electricity and oil. In 1970, oil accounted for 17% of the total and electricity 5%. In 2001, oil accounted for 6% and electricity for 10%.

By 2001 renewable energy sources accounted for 1% of the total. Around 85% or more of this was wood consumption, which has been included within the solid fuel category in the delivered energy figures presented in Tables 30 and 33.

The total primary energy consumption of the UK housing stock rose by 27% between 1970 and 2001. As noted earlier, the delivered energy consumed by the GB housing stock rose by 31.5% over the same period, indicating that there has been an improvement in the primary energy ratio for the housing stock. In other words, the primary energy is being used more effectively with fewer losses between the production and delivery stages of the overall energy balance.

Primary energy consumption

Table 32. Primary energy consumption (PJ) - UK figures

Year	Solid	Oil	Gas	Renewables	Electric	Total
1970	1597.2	410.2	292.2	0.0	124.6	2424.3
1971	1440.3	445.8	409.0	0.0	130.9	2426.1
1972	1302.4	562.1	526.3	0.0	145.4	2536.3
1973	1380.6	537.0	536.2	0.0	135.6	2589.4
1974	1272.0	535.2	639.8	0.0	169.4	2616.4
1975	1237.9	424.1	696.9	0.0	148.4	2507.3
1976	1188.1	360.2	715.3	0.0	164.5	2428.1
1977	1205.9	365.7	768.0	0.0	179.1	2518.7
1978	1159.4	376.6	825.7	0.0	164.6	2526.3
1979	1236.3	361.0	939.3	0.0	169.2	2705.8
1980	1204.4	263.3	953.1	0.0	165.0	2585.7
1981	1171.7	211.8	1000.2	0.0	169.5	2553.2
1982	1097.1	227.9	986.5	0.0	197.0	2508.6
1983	1081.5	192.4	1040.2	0.0	219.5	2533.6
1984	749.7	483.8	1045.4	0.0	232.5	2511.4
1985	1017.6	300.2	1146.9	0.0	265.9	2730.5
1986	1099.7	229.4	1217.9	0.0	257.6	2804.7
1987	1076.4	213.4	1236.8	0.0	238.2	2764.8
1988	999.3	219.4	1190.8	11.6	263.5	2684.6
1989	927.6	216.3	1142.1	11.7	274.8	2572.5
1990	916.1	243.7	1196.7	11.3	253.8	2621.5
1991	950.8	251.1	1334.3	12.0	281.2	2829.3
1992	889.5	258.7	1337.4	12.4	301.3	2799.2
1993	789.4	234.6	1484.7	17.7	344.1	2870.4
1994	721.7	209.0	1446.2	20.7	346.2	2743.8
1995	653.1	208.0	1493.9	21.3	336.5	2712.8
1996	672.3	233.2	1761.3	20.1	348.7	3035.5
1997	560.8	192.0	1705.5	24.8	350.8	2833.9
1998	591.9	194.9	1778.9	25.1	363.1	2953.9
1999	527.1	174.8	1836.3	28.4	345.8	2912.4
2000	548.1	176.2	1900.1	32.4	303.7	2960.5
2001	604.7	188.1	1930.5	36.9	319.6	3079.9

Source: Department of Trade and Industry

Delivered energy use by the UK housing stock

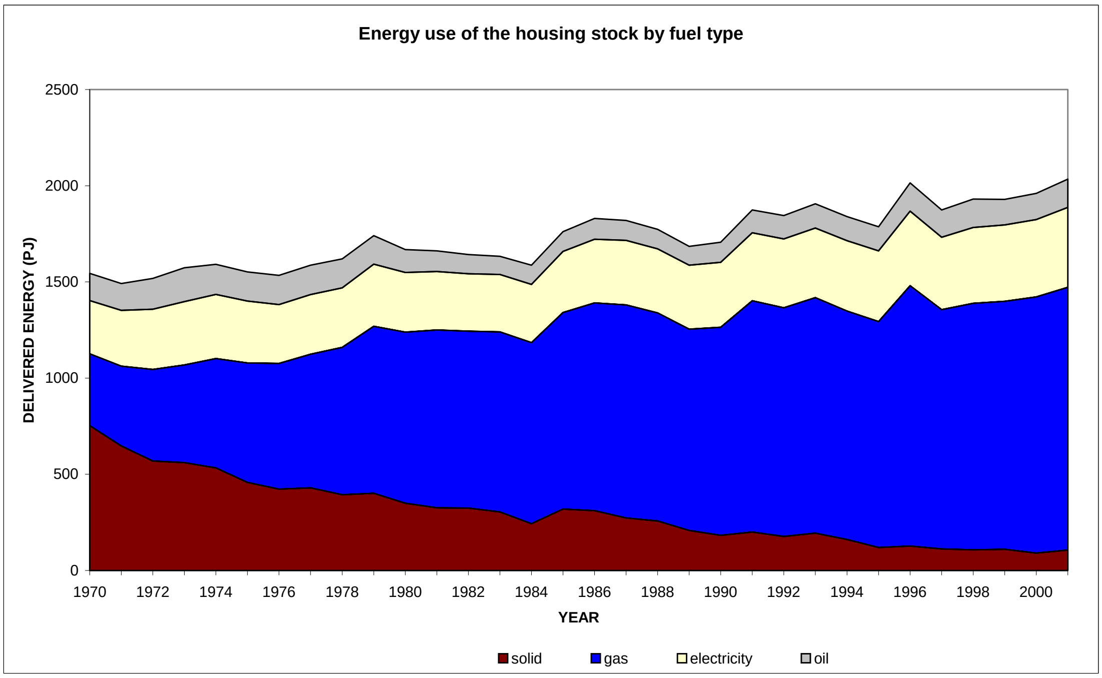


Figure 33. Energy use of the housing stock by fuel type

In order to illustrate the improvement in the domestic sector primary energy ratio it is necessary to compare the delivered energy figures with the primary energy figures presented in Table 32. Delivered energy figures were shown in Table 30 but these were for GB. To compare with Table 32 the equivalent figures for delivered energy for the UK housing stock are needed. These are given in Table 33, illustrated in Figure 33. Obviously, they are quite similar to the GB figures.

Delivered energy use by the UK housing stock

Table 33. Energy use of the housing stock by fuel type (PJ) - UK figures

Year	Solid	Gas	Electricity	Oil	Total
1970	752.7	373.6	277.3	140.8	1544.4
1971	647.1	414.5	290.5	139.3	1491.5
1972	569.2	475.6	312.8	160.6	1518.2
1973	560.9	507.8	328.6	175.9	1573.3
1974	533.6	567.8	333.4	156.3	1591.1
1975	458.1	621.4	321.1	151.2	1551.8
1976	422.8	653.3	306.4	151.4	1533.9
1977	429.5	695.0	309.3	153.0	1586.8
1978	394.0	765.8	308.9	151.2	1620.0
1979	401.9	867.5	322.9	148.2	1740.4
1980	349.4	890.1	310.0	118.7	1668.1
1981	325.9	924.3	304.0	106.9	1661.2
1982	324.6	919.6	297.9	99.9	1642.0
1983	304.5	935.6	298.5	94.9	1633.5
1984	242.7	942.2	302.0	99.9	1586.7
1985	319.6	1021.4	317.5	102.7	1761.1
1986	310.7	1080.1	330.4	108.4	1829.7
1987	273.1	1107.5	335.6	103.6	1819.7
1988	257.3	1081.6	332.4	102.2	1773.6
1989	208.2	1046.2	332.2	98.6	1685.2
1990	182.9	1081.7	337.7	103.8	1706.2
1991	200.1	1202.5	353.2	118.3	1874.2
1992	176.9	1188.6	358.2	121.0	1844.7
1993	193.8	1224.9	361.7	126.4	1906.8
1994	161.6	1187.2	365.1	125.8	1839.7
1995	119.7	1173.9	368.0	125.5	1787.1
1996	127.0	1353.3	387.1	147.3	2014.7
1997	112.4	1244.0	376.1	141.9	1874.4
1998	107.3	1281.3	393.9	148.3	1930.8
1999	110.2	1289.1	397.1	132.4	1928.8
2000	90.4	1331.7	402.7	135.6	1960.4
2001	106.8	1365.0	415.2	147.0	2034.1

Source: Digest of United Kingdom Energy Statistics

Primary energy ratios

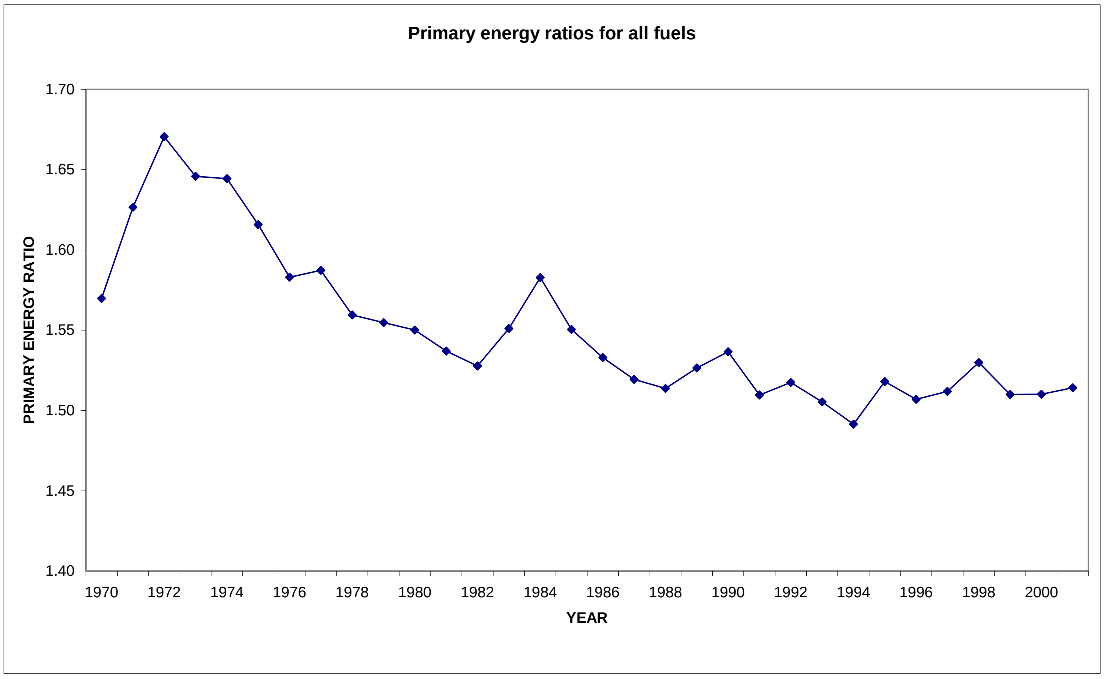


Figure 34. Primary energy ratios for all fuels

Table 34 shows the total domestic sector primary energy consumption taken from Table 32 and the delivered energy consumption taken from Table 33. The ratio of the two figures is known as the primary energy ratio as shown in Table 34 and illustrated in Figure 34. This was 1.57 in 1970. It rose to a maximum of 1.67 in 1972 and has fallen to 1.51 in 2001, a value that it has maintained for several years.

Primary energy ratios for individual fuels are more difficult to determine than the overall ratio. It is important to recognise, however, that there are marked differences between the ratios for different fuels. For example the ratio for electricity in 1995 would have been about 2.8. For gas the ratio would have been about 1.15 whilst that for oil would have been about 1.19 and for coal about 1.07 (secondary solid fuels such as coke and breeze have much higher primary energy ratios).

For electricity, the ratio between primary energy consumption and delivered energy is necessarily quite high, although it has improved considerably over the years. It does need to be noted, however that there are several complications involved in relating delivered energy to primary energy for electricity. For some end uses it is possible for consumers to save money by switching from using on-peak to off-peak electricity. Such a switch may not involve either an increase or a saving of delivered energy. However, using more off-peak electricity and less on-peak electricity helps to even out the daily demand variations. This means that power stations are able to run more continuously which, in turn, means that the conversion process becomes more efficient. The net effect, therefore, is that primary energy consumption is reduced.

Primary energy ratios

Table 34. Primary energy ratios for all fuels - UK figures

Year	Primary energy consumption (PJ)	Delivered energy (PJ)	Primary energy ratio
1970	2424.3	1544.4	1.57
1971	2426.1	1491.5	1.63
1972	2536.3	1518.2	1.67
1973	2589.4	1573.3	1.65
1974	2616.4	1591.1	1.64
1975	2507.3	1551.8	1.62
1976	2428.1	1533.9	1.58
1977	2518.7	1586.8	1.59
1978	2526.3	1620.0	1.56
1979	2705.8	1740.4	1.55
1980	2585.7	1668.1	1.55
1981	2553.2	1661.2	1.54
1982	2508.6	1642.0	1.53
1983	2533.6	1633.5	1.55
1984	2511.4	1586.7	1.58
1985	2730.5	1761.1	1.55
1986	2804.7	1829.7	1.53
1987	2764.8	1819.7	1.52
1988	2684.6	1773.6	1.51
1989	2572.5	1685.2	1.53
1990	2621.5	1706.2	1.54
1991	2829.3	1874.1	1.51
1992	2799.2	1844.7	1.52
1993	2870.4	1906.8	1.51
1994	2743.8	1839.7	1.49
1995	2712.8	1787.1	1.52
1996	3035.5	2014.4	1.51
1997	2833.9	1874.4	1.51
1998	2953.9	1930.8	1.53
1999	2912.4	1928.8	1.51
2000	2960.5	1960.4	1.51
2001	3079.9	2034.1	1.51

Source: Department of Trade and Industry

Energy balance of the housing stock

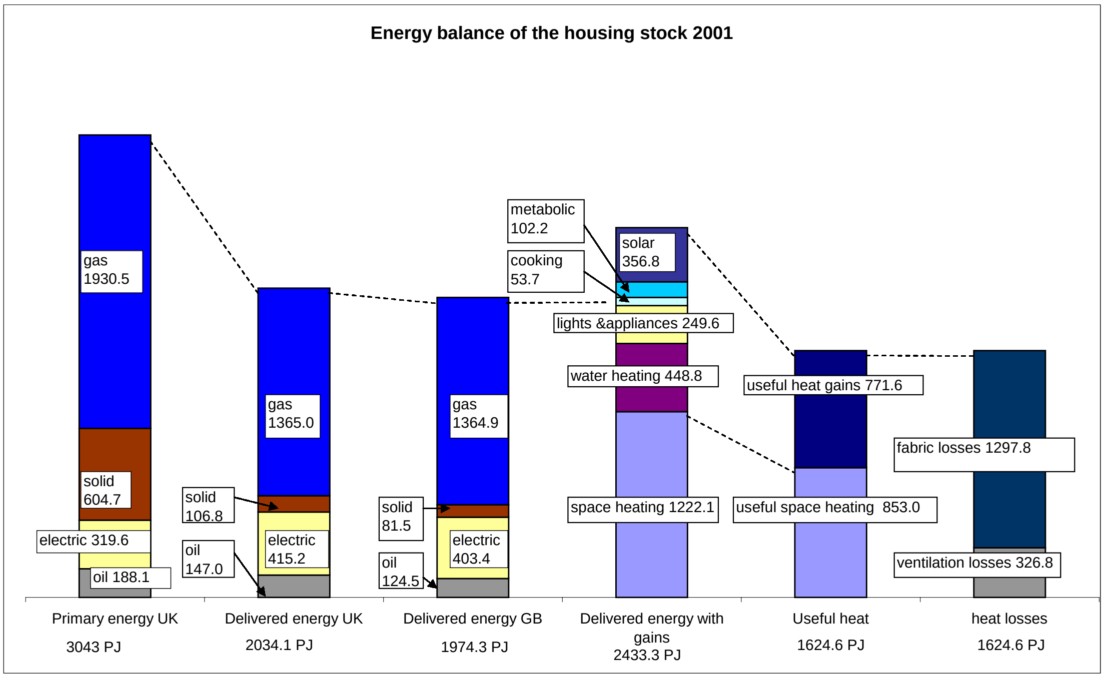


Figure 35. Energy balance of the housing stock - 2001

Figure 35 illustrates the scale of the housing stock related energy flows for 2001. The figure shows the relationships between primary energy, delivered energy, useful heat and the housing stock losses. Some of the figures in the energy balance are known quite accurately (e.g. delivered gas) while others are more uncertain (e.g. useful heat gains). However, all numbers are undoubtedly of the right order.

The first block in the diagram shows that part of the national primary consumption which is related to the housing stock.

The amount of energy and the fuels actually delivered are shown in the second block. The difference between the first and the second block is the losses associated with conversion, transmission and distribution, as well as the energy used by the energy industries themselves.

Domestic energy flow figures for the whole of the United Kingdom are difficult to ascertain so the third block shows only the delivered energy for Great Britain – i.e. figures for Northern Ireland are excluded.

The fourth block shows the same delivered energy as the third, augmented by natural gains (solar and metabolic). This block illustrates the end uses of the delivered energy rather than the fuels delivered.

The fifth block shows that part of the total delivered energy which supplies useful heat. A part of the useful heat is supplied directly by the energy delivered for space heating (reduced according to the average efficiency of heating systems). The rest is supplied as incidental heat gains from lights, appliances, cookers, hot water systems and natural gains. Only a part of the potential incidental heat gains are useful. In summer, for example, a large proportion of incidental gains are deliberately rejected because they would otherwise cause overheating. Even in winter, part of the potential incidental gains are lost. For example, a large part of the potential gains from hot water are lost as water flows away through the drains. Similarly, much of the heat produced by cooking is often lost through extraction to the outside.

Energy balance of the housing stock

The sixth block shows how the useful heat is lost to the external environment through the fabric and ventilation losses associated with the national housing stock. Any reduction in losses at this stage, such as improved insulation, will effectively reduce the primary energy input shown in the first block. This can also be achieved through improvements to other parts of the overall energy balance:

- The losses between the fourth and fifth block can be reduced through improvements to the efficiencies of heating systems and by recovery of incidental gains which are lost.

- The solar heat gains can be increased by solar design features and appropriate orientation. Such “passive solar” techniques result in a reduced proportion of the useful heating being supplied by the heating system – and, hence, a reduced amount of fuel has to be delivered for space heating.

- A given delivered energy requirement can be supplied from a reduced amount of primary energy by reducing the losses between the first and second blocks. This can be done, for example, by improving conversion efficiency or by the energy industries reducing the amount of energy which they themselves use.

References and sources

1. Domestic Energy Fact File 1998. G A Walters and L D Shorrock. BRE report BR 354.1998.

2. Carbon emission reductions from energy efficiency improvements to the UK housing stock. L D Shorrock, J Henderson, J I Utley and G A Walters. BRE report BR435.2001.

3. Digest of United Kingdom Energy Statistics. Department of Trade and Industry. Published annually

4. Family Expenditure Survey. Office for National Statistics. Published annually, recently replaced by Expenditure and Food Survey. Office for National Statistics.

5. Domestic energy fact file: England, Scotland, Wales and Northern Ireland. J I Utley, L D Shorrock, J H F Bown. BRE report BR 427 2001

6. General Household Survey. Office of Population Censuses and Surveys. Published annually.

7. The Government's Standard Assessment Procedure for Energy Rating of dwellings. 2001 edition. Published on behalf of DEFRA by BRECSU, BRE. November 2001.

8. Domestic Sector Analysis. 1976/77 to 1986/87. Electricity Council. 1988

9. Domestic Equipment and Carbon Dioxide Emissions. Second year report. Environmental Change Unit, University of Oxford. 1995.

10. A National Field Survey of House Temperatures. D R G Hunt and M I Gidman. Building and Environment, 17 (2). 1982.

11. English House Condition Survey, 1991 Energy Report. Department of the Environment Transport and the Regions. 1996.

12. English House Condition Survey, 1996 Energy Report. Department of the Environment Transport and the Regions. 2000.

13. Energy Efficiency of the English housing stock in 1998. Energy Follow Up Survey. Unpublished.

14. English House Condition Survey, 2001 Energy Report. To be published

15. A detailed analysis of the historical role of energy efficiency in reducing carbon emissions from the UK housing stock. L D Shorrock. To be published in the proceedings of the ECEEE 2003 Summer Study. June 2003

In addition to the detailed references the following sources have been consulted:

GfK Home Audit. GfK Marketing Services Ltd. Home heating and insulation ownership reports. Published annually.

Annual Abstract of Statistics. Central Statistical Office. Published annually.

Housing and Construction Statistics. Great Britain. Department of Environment Transport and the Regions, Scottish Development Department, Welsh Office. Published annually.

BSRIA market research reports on domestic heating in the UK:
The Domestic Central Heating Market in Great Britain. BSRIA report MR 3/92. June 1992
European Space and Water Heating. Domestic Boilers. United Kingdom. BSRIA report 14847/6. April 2000.

Also the following web sites have been consulted to obtain some information:

www.statistics.gov.uk

www.defra.gov.uk

www.dti.gov.uk/energy

www.housing.odpm.gov.uk

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