**Joint Working Group on Energy and the Environment.**

**Progress on the development of indicators – July 2005**

## Background

1. The JWGEE indicators sub-Group has met four times to discuss the development of a suite of indicators. Progress for each of the four main sectors (household, industry, services and transport), together with an overview of the general approach, is described below. Most progress has been made on household indicators, but work is underway on the industrial, transport and services sectors. A summary of the household sector analysis is shown at Annex A. A more technical report describing the methodology behind the household indicators is currently in preparation, and will be available shortly.

## General approach

2. The suite of indicators will provide a breakdown of the high level carbon dioxide emissions Public Service Agreement target indicator by examining the key factors influencing it. This will enable a better understanding of what is helping – and what is hindering – progress towards our domestic and international targets. The sub-Group agreed that a sectoral approach should be used, and that the main areas where indicators should be developed were:

- carbon emissions,
- final energy consumption,
- energy efficiency, and
- energy service demand.

3. These areas would be sub-divided further to examine the main energy uses, and associated technologies and related factors. For instance when examining household indicators, the main uses would include space heating, hot water provision, cooking and lighting & appliances; technologies would include cavity wall and loft insulation; and related factors would include internal temperatures and output from lighting.

4. Where possible the indicators would be based on real data, and cover a time period dating back to at least 1990, but it was recognised that the majority were likely to contain at least an element of modelled data due to a lack of measured data. Projected impacts (to 2010) were also desirable.

## Household Sector

5. Work in this sector is well advanced and we are in a position to publish (attached at Annex A) indicators of efficiency improvement, energy service demand and energy consumption for the historic period 1970-2003; many are also projected through to 2010.

6. Annex A also contains charts showing the uptake over time of individual energy efficiency technical measures (eg insulation); however linking these and the overall efficiency indicators to particular policies is

dependent on the outcome of the appraisals being conducted under the Climate Change Programme review, reporting later this year. As regards tracking progress towards 2010 goals, this will require several years' more data to reduce the annual uncertainty arising from weather and normal market fluctuations. With the exception of the Homes Insulation Scheme in the 1980s, effective policies – specifically the Energy Efficiency Commitment and the application of building regulations to replacement boilers and windows – began only in 2002.

7. There are two areas where further field monitoring is essential. The first is the actual energy savings delivered by technical measures in real households. Theoretical or test-house savings can be reduced by underperformance on site, higher direct rebound effects (eg comfort-taking), or other factors overlooked in the modelling assumptions. Several projects have been completed and more are underway, with mixed results in terms of confirming current assumptions. The situation is expected to become much clearer by mid-2006.

8. The second area is measurement of the levels of – and annual changes in – the underlying demand for the different energy services, to check against the current values, which are derived as the "difference" between changes in consumption and efficiency. One study on heating patterns will be completed in the spring, but longer term studies are required to measure time trends.

**Industrial Sector**

9. The starting point for determining indicators of energy efficiency in industry has been a disaggregated analysis of industrial energy consumption, building on work previously commissioned by Defra to look at industrial energy use and $CO_2$ emissions. This earlier work covered manufacturing industry, split into 16 sectors over the period 1990-1998.

10. In the current work, the data series are being revised by taking account of new information on industrial production and energy use and extended to include more recent years. The information is largely being taken from published sources, but for some sectors permission has been given to use data obtained through the Climate Change Agreement (CCA) process. Currently, we have received this permission from six sectors. The analysis is calculating indices relative to the base year for energy consumption, useful energy demand and specific energy consumption. These indices will then be chained to give trends in energy efficiency, as measured by specific energy consumption. A complete set of first results for all sectors will be available in the late summer.

11. Improvements in energy efficiency in industry arise largely from technological change. In the next phase of the project, it is proposed to perform an analysis for the largest energy using sectors to try and identify the technological changes that have been most important in driving trends in energy efficiency. The analysis will be based on information from industry, from CCAs and from the ENUSIM energy simulation model. Further

discussions are needed to agree the precise outputs required from this stage of the work.

**Services Sector**

12. Work on developing indicators for this sector is still in its initial stages. The general approach is likely to be similar to that for the household sector, as consumption is dominated by building services (eg space and water heating, lighting, ventilation/cooling), but with a variety of other specialised end uses in different sub-sectors, eg catering in hotels and restaurants ("Hospitality"), refrigeration in Retail and Hospitality, pumps and dehumidification equipment for swimming pools in Sport and Leisure.

13. Sub-sectors are likely to include Education, Health, Central and Local Government (excluding housing and education), Retail, Hospitality, Sport and Leisure, Commercial Offices, Communications and Transport, and Warehouses. One major difficulty is the lack of any long term consumption data by sub-sector. Our current breakdown is derived from floor area data from the Land Registry in conjunction with data on energy consumption per unit floor area, based on a one-off survey exercise conducted in the mid-late 1990s. Since consumption per unit floor area might be a possible intensity indicator – or even efficiency indicator for some end-uses – we would need to measure this annually (which would be very expensive) or else find an alternative source of disaggregated consumption data which is accurately updated annually.

14. Annual sales or installation rates of the main energy efficiency technical measures will be required to construct trends of energy efficiency improvements.

**Transport sector**

15. Work for this sector began in the new financial year. A meeting was held early in the year with the Department for Transport, who agreed to lead on the development of indicators in this sector. Indicators will be developed using road, rail and aviation data.

16. The approach being taken is to examine different modes of transport and identify both changes in efficiency and changes in transport service demand. Some indicators already exist (such as the SAVE suite of transport indicators) which maybe developed further. Information on behavioural changes will be incorporated where available.

**Contact**

17. For further information on the development of these indicators please contact Julian Prime (email: julian.prime@dti.gsi.gov.uk).

**Annex A**

# Household Sector Energy Indicators

*Summary*

1. A set of indicators has been developed to track the energy performance of households. The key points are:

- Natural gas now provides 70% of household energy, and represents around 55% of carbon emissions. Space heating is responsible for 60% of energy use, and around 55% of the carbon.
- Headline indicators of consumption, energy service demand and energy efficiency show a fine balance between service demand increases and efficiency improvements. Consumption per household has been almost static since 1990, but increasing household numbers caused total consumption to rise at around 1% p.a.
- Heating and hot water system improvements raised overall energy efficiency by around 10% between 1990 and 2003, with a further 10% from better insulation, split between new build and retrofit measures. Electrical appliance efficiency improved by around 20%, though its overall effect is small in comparison.
- Demand fluctuations due to weather variations make it difficult to distinguish early Climate Change Programme effects from underlying trends at this stage, but significant changes should become visible within the next 2-3 years.
- Understanding domestic energy use and carbon emissions relies on a wide range of data. More direct monitoring of household comfort standards, as well as of energy efficiency technologies, will be crucial to accurate progress tracking.

*Introduction*

2. Energy indicators for UK households have been developed to illustrate how consumption and carbon emissions depend on the demand for the various services that require energy, and the efficiency with which these services are delivered. As an aid to tracking progress towards Climate Change Programme goals, the analysis underlying these indicators potentially provides links, both with policy measures – past, present and planned – and with projections of future energy demand and carbon emissions.

*Structure and Scope*

3. The top level indicators of energy consumption, carbon emissions, efficiency and service demand are built on a simplified framework comprising:

    - four energy services: space heating, hot water, lights & appliances and cooking; and

- the range of technologies that affect efficiency: housing construction standards, insulation, heating systems, glazing materials, lighting and appliance specifications, etc.

4. Consumption and emissions trends are derived from published energy statistics[1]. Technology trends are built up from survey and sales data. Breaking down usage between the four energy services relies on surveys and models to provide a coherent and consistent picture over a period of time[2]. This paper concentrates on the period since 1990, but the analysis stretches back to 1970, and projects forward to 2010.

5. Service demand trends are, at present, largely derived from the energy consumption data and model output. Of most importance is space heating, for which demand is determined by the combination of internal temperatures and the weather outside. Direct measurements of internal temperatures are sparse[3], and more systematic monitoring is needed to validate the modelled trends[4]. Some areas of demand – such as home entertainment – are particularly complicated and simplifying assumptions are needed.

6. Two complicating factors which have been addressed specifically in the indicators framework are:

   - interactions between energy services: primarily the heating contribution from lights and appliances, and other incidental heat sources such as solar radiation and dwelling occupants
   - comfort and rebound effects – which apply especially to insulation measures – in which a fraction of any efficiency improvement translates into increased demand (i.e. warmer homes) rather than reduced consumption.

   Further details of the indicator methodology and analysis are being made available in a more extensive technical paper[5].

*Energy Use and Carbon Emissions*

7. Delivered energy consumption for the UK household sector is currently averaging around 2000 PJ per year. Weather has a strong influence on year-to-year heating demand, but the underlying trend is almost flat. Figure 1 below shows that of the total demand, space and water heating make up over 80%, and of this heating load about 80% is currently met by gas, which has displaced solid fuel to a large extent since 1990. Water heating is of growing importance in new housing, as heating fuel demand is diminished by improving insulation standards. Of electricity demand,

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[1] *Digest of UK Energy Statistics*.

[2] Especially the Building Research Establishment *BREHOMES* model, based on GfK surveys, together with the English House Conditions Survey, and various Market Transformation Programme projects. The *BREHOMES* data up to 2001 are published in the *Domestic Energy Fact File 2003*.

[3] Mainly pre-1990, though there are some recent surveys, e.g. by the Fuel Poverty Programme.

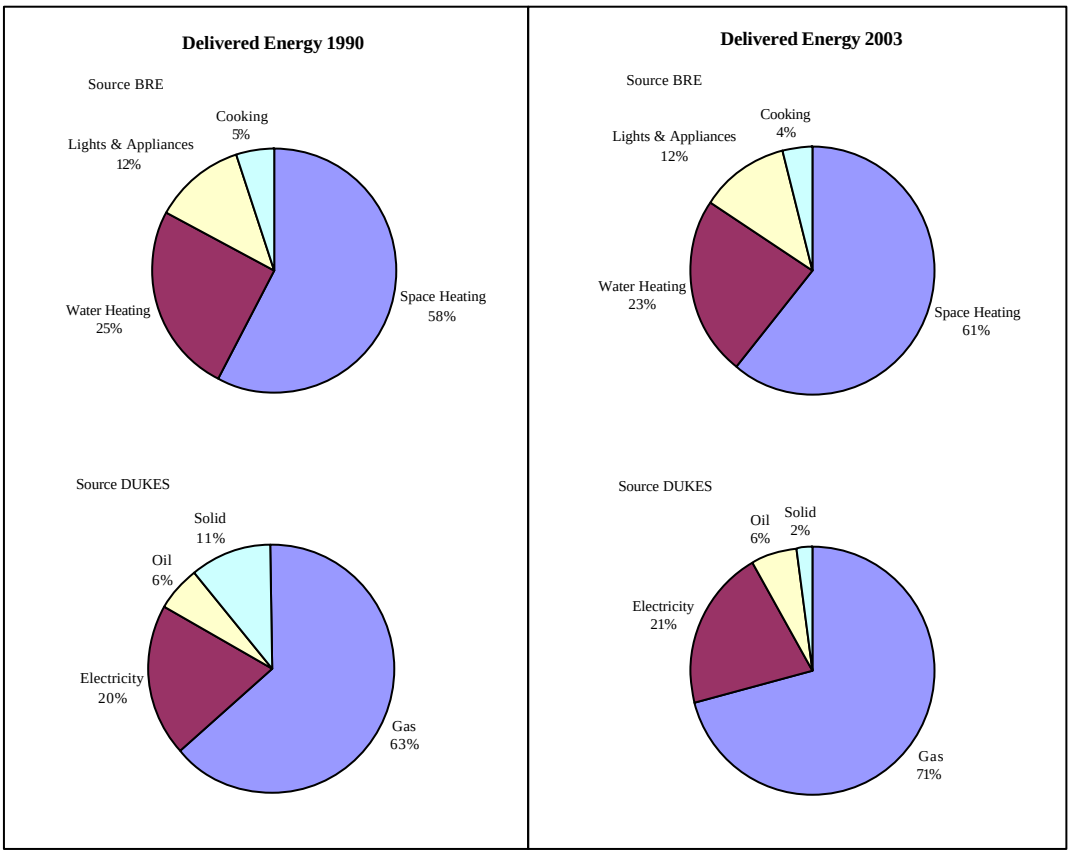
[4] This applies also to hot water demand.

[5] Defra, in preparation.

around 60% is used in lighting and appliances[6], and around 20% for space heating.

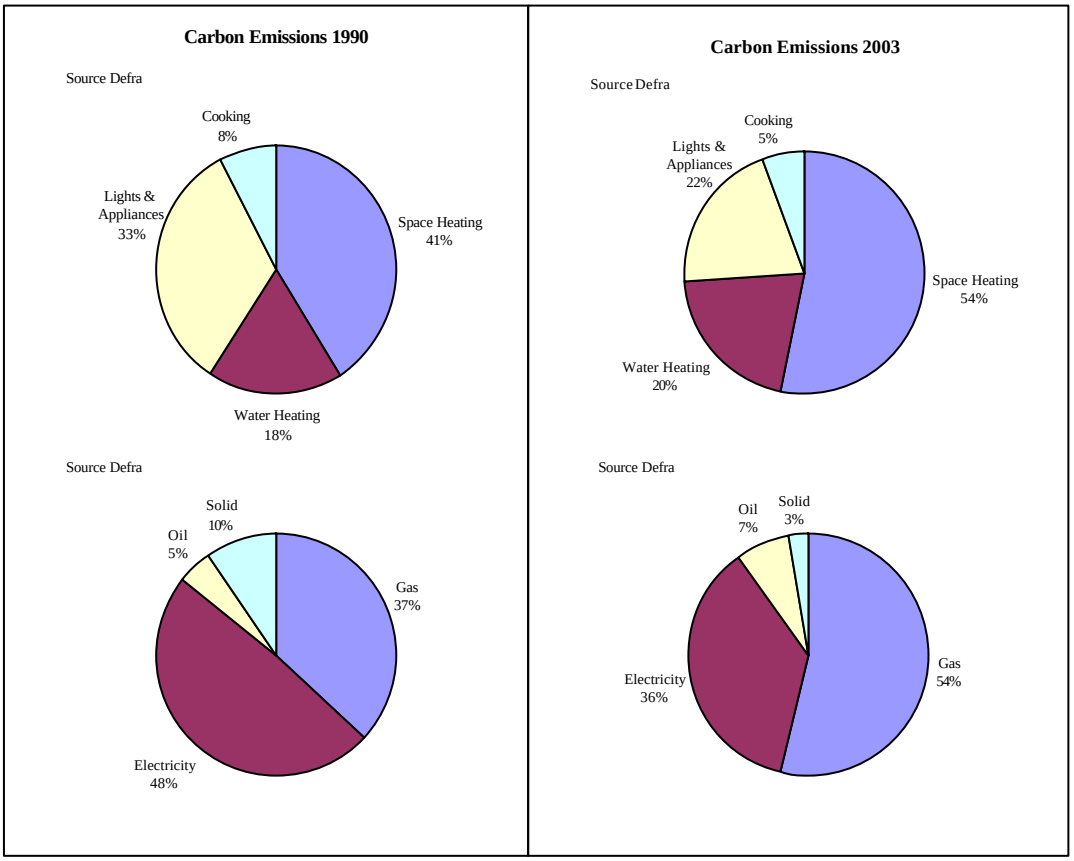
8. Carbon emissions in 2003 amounted to around 37 MtC[7]. This is a significant reduction from the 1990 emissions of about 42 MtC, mainly due to a steep fall in the carbon intensity of electricity generation, and phasing out of domestic solid fuel. Together these changes more than offset the increased carbon from natural gas. Since electricity has a much higher emission factor than gas, lights and appliances are more important for carbon than for energy, and make up over 20% of the total emissions.

**Figure 1(a): Household Energy by End Use and by Fuel**




[6] In this paper, appliances associated with food and drink preparation are included in 'cooking'.
[7] Using carbon emission factors from the Defra *Guidelines for Company Reporting on Greenhouse Gas Reporting* for year 2000 onwards, and ETSU/Defra factors for electricity generation 1990-1999.

**Figure 1(b): Household Carbon Emissions by End Use and by Fuel**




*Main Household Sector Indicators*

9. Figure 2 below gives the top level indices for consumption, efficiency and service demand, and Figures 3 – 5 show the breakdown by end use category.

10. There is a fine balance between service demand and efficiency improvements, such that consumption has been increasing slowly – by just under 1% per annum over the past decade, with consumption per household static. The aim of the Climate Change Programme policies is to reverse this balance ('doubling of the rate of energy efficiency improvements'), so that total consumption begins to fall.

**Figure 2: Consumption, Efficiency and Service Demand**

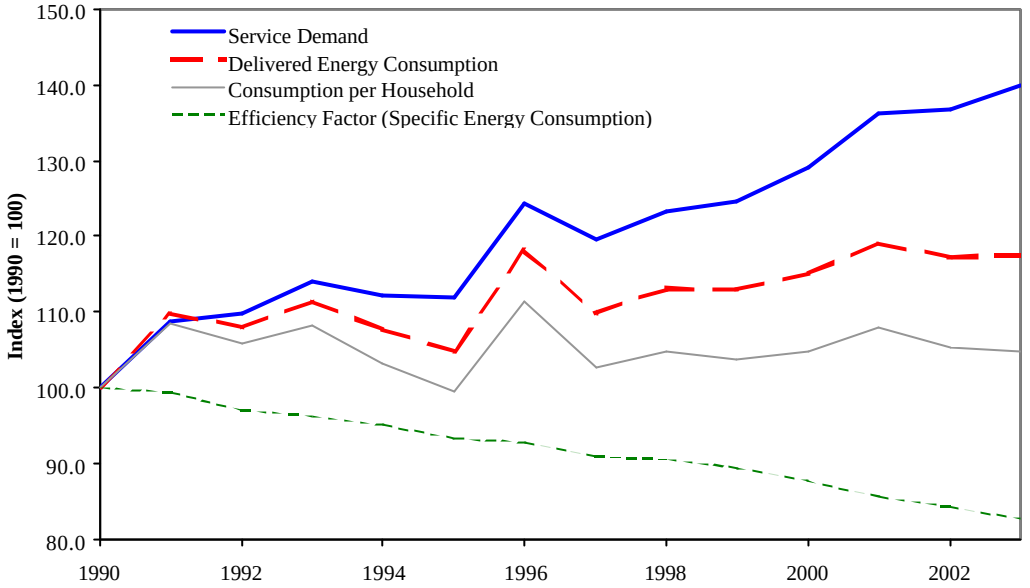
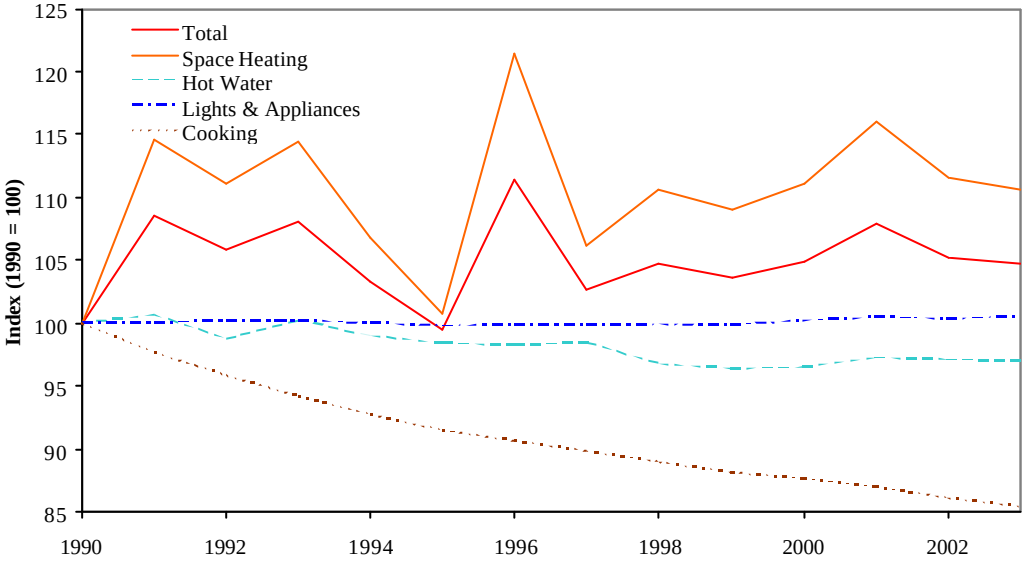



**Figure 3: Delivered Energy Consumption per Household**




11. Service demand has been driven by increasing comfort standards (heating and hot water), and a steady rise in the number of light fittings and household appliances (notably exterior lighting and digital entertainment equipment in recent years). Energy efficiency improvements have been most important in the areas of insulation (loft and cavity walls) and central heating (boiler efficiency). Appliance efficiency improvements have also been considerable in percentage terms, and compact fluorescent lamps are making an impact on lighting energy demand.

**Figure 4: Energy Efficiency (Specific Energy Consumption)**

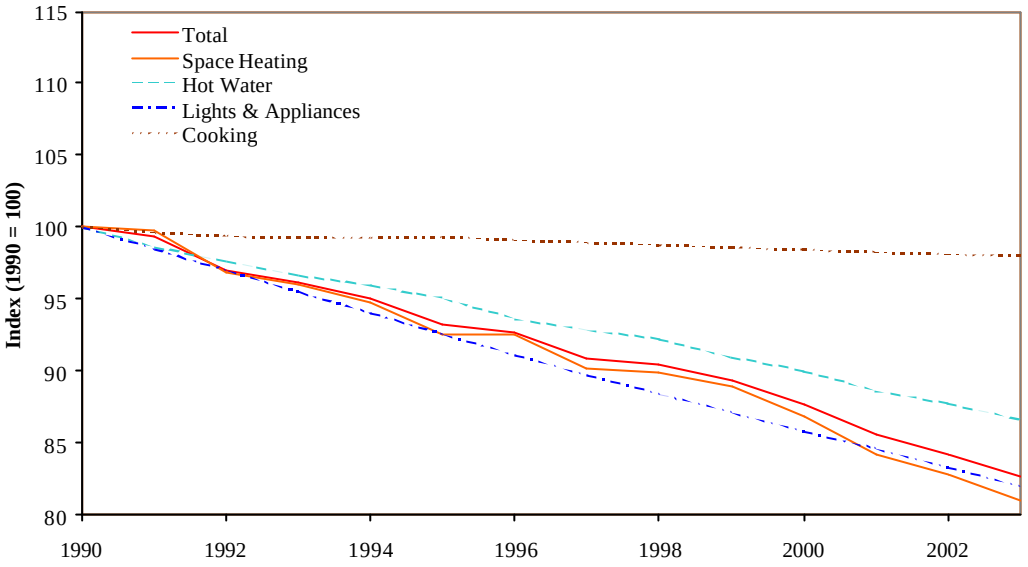
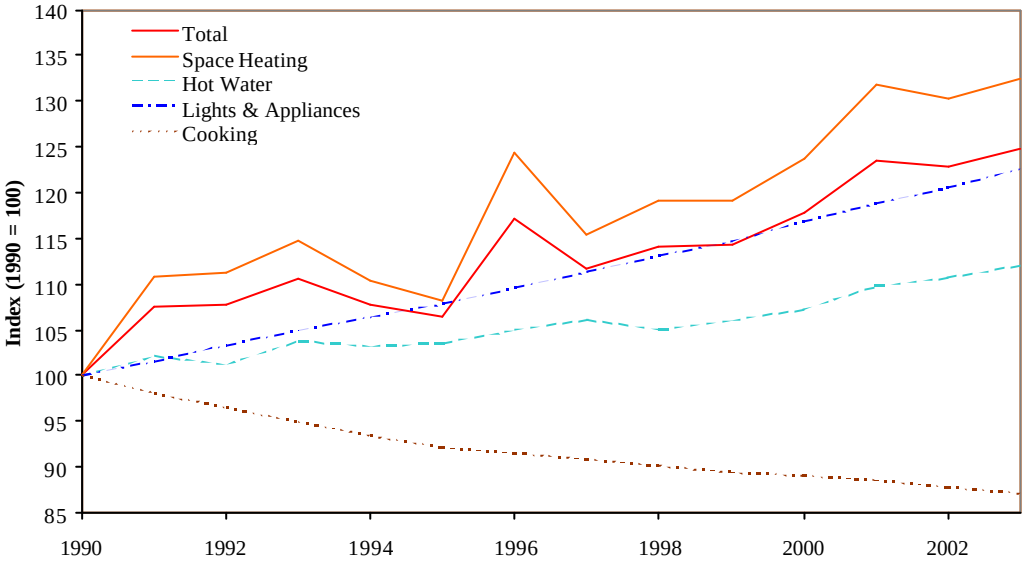



**Figure 5: Service Demand per Household**

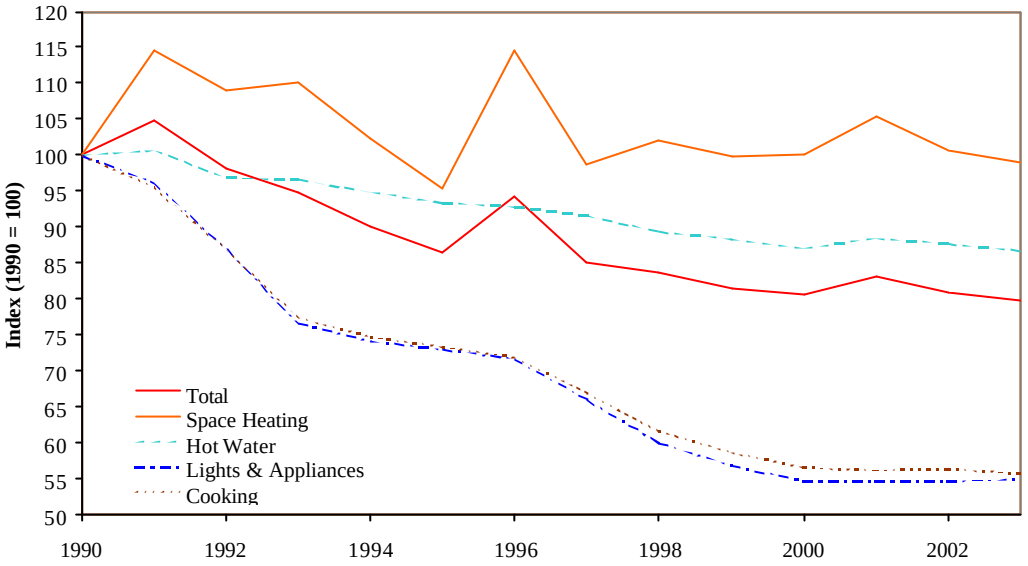



12. The most important area by far is space heating, which makes up about 2/3 of delivered energy demand, and is governed by three main factors: insulation, heating system efficiency, and incidental gains from lights & appliances, cooking, solar radiation, and dwelling occupants.

13. Figure 6 reproduces Figure 3 in terms of carbon emissions. The carbon trend for space heating fluctuates due to the weather, and the underlying trend is relatively small. The main differences between the carbon and energy trends for the other end uses arises from the 'dash for gas' in

electricity generation, which is responsible for a strong downward trend in the emission factor[8].

**Figure 6: Carbon Emissions per Household**




*Contributions of Energy Efficiency Technologies*

14. Figure 7(a) below breaks down the overall efficiency trend of Figure 4 into its main components. Since 1990, the most important of these has been the improvement in central heating boiler efficiency. Building regulations have ensured that new build improves the average efficiency significantly, even though annual new house completions represent less than 1% of the stock. Of similar importance has been insulation, which here includes double glazing as the main contributor, with increasing savings from cavity wall insulation, and a continuing top-up of loft insulation[9]. The net energy saving from lights and appliances is relatively small because of the interaction with heating[10], despite major efficiency gains, but the carbon saving is important because of the high emission factor of electricity.

15. Figure 7(b) shows the total carbon emissions for UK households over the period, illustrating the extent to which energy efficiency measures – both new build and retrofit – are estimated to have reduced emissions.

16. Most of the carbon reductions due to energy efficiency improvements since 1990 are due to 'business as usual' activities rather than specific Climate Change Programme measures, and on this scale it is difficult to pick out specific programme contributions before 2002. Exceptions are the HEES programme, which made a modest improvement to loft insulation

[8] The striking similarity of the shapes for the lights & appliances and cooking carbon trends is partly due to their both being dominated by the electricity factor changes, but their proximity all the way through the period is coincidental – they follow very different paths during the 1980s.
[9] Most lofts were insulated to some degree by 1990.
[10] The so-called heat replacement effect.

standards through the 1990s (equivalent to around 0.3MtC/yr[11]), and the labelling schemes which have been driving the transformation of the cold and wet appliances markets in very recent years (probably of the order of 1MtC, in conjunction with delivery programmes). Programme influence in terms of numbers of measures is addressed further below.

**Figure 7(a): Breakdown of Efficiency Trends 1990-2003**

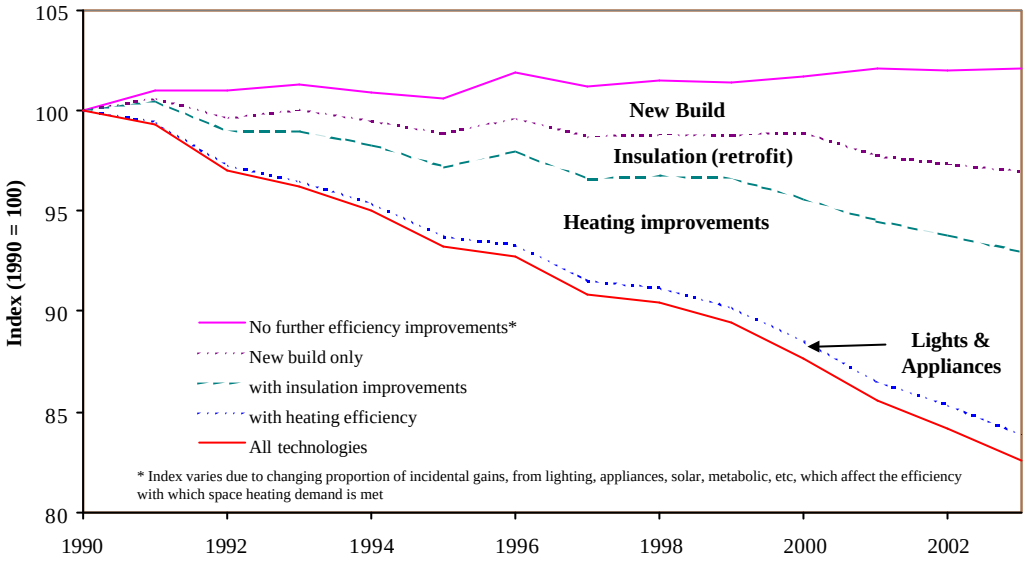
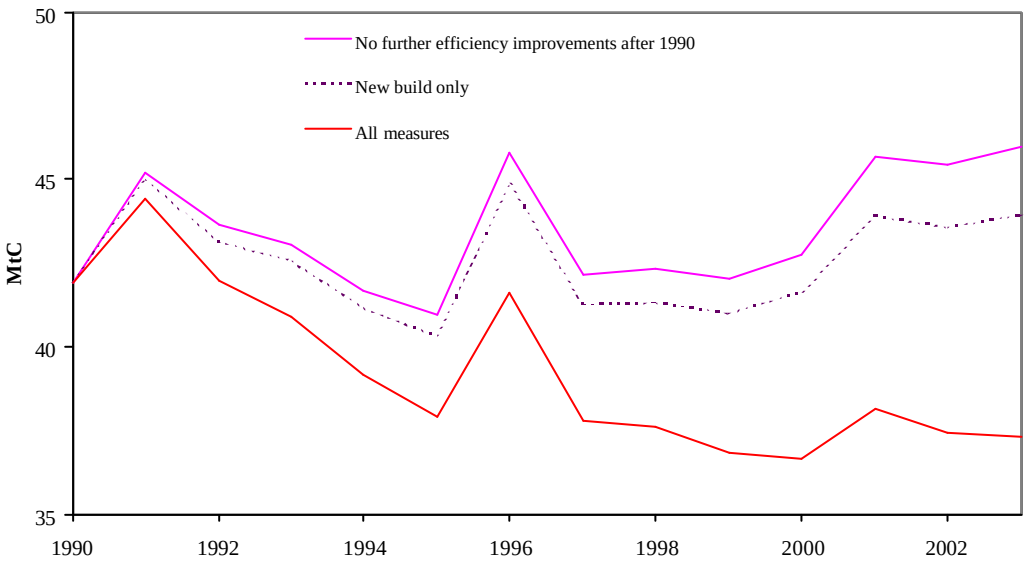



**Figure 7(b): Estimated Carbon Emissions for UK Households**

(using Defra Guidelines emission factor for electricity 2000-2010)




[11] Assuming that the dwellings insulated are occupied by average households.

*Supporting Indicators*

17. Underlying the analysis of energy efficiency trends is a wide range of technology-related data, and Table 1 lists the main sources.

**Table 1: Information Sources for Main Energy Technologies**

| Technology / End use | Source | Comment |
|---|---|---|
| Boiler acquisitions | SBGI sales data by SEDBUK efficiency band | Good market coverage post 2000 |
| Efficiency of boiler stock | BREHOMES model | From GB energy balance |
| Heating demand | BREHOMES model | Derived temperature trend |
| Insulation acquisitions | GfK surveys, + manufacturers, EEC & Warm Front returns | GfK sample size small; other data used for cross checking |
| Insulation ownership | English House Conditions Survey & GfK | Now annual, but small samples; needs scaling |
| Insulation performance | Various studies, mainly linked to SoP and EEC | Pilot studies need wider follow-up |

18. Figures 8 and 9 illustrate the ownership of insulation within the total housing stock.

**Figure 8: Ownership of Loft Insulation**

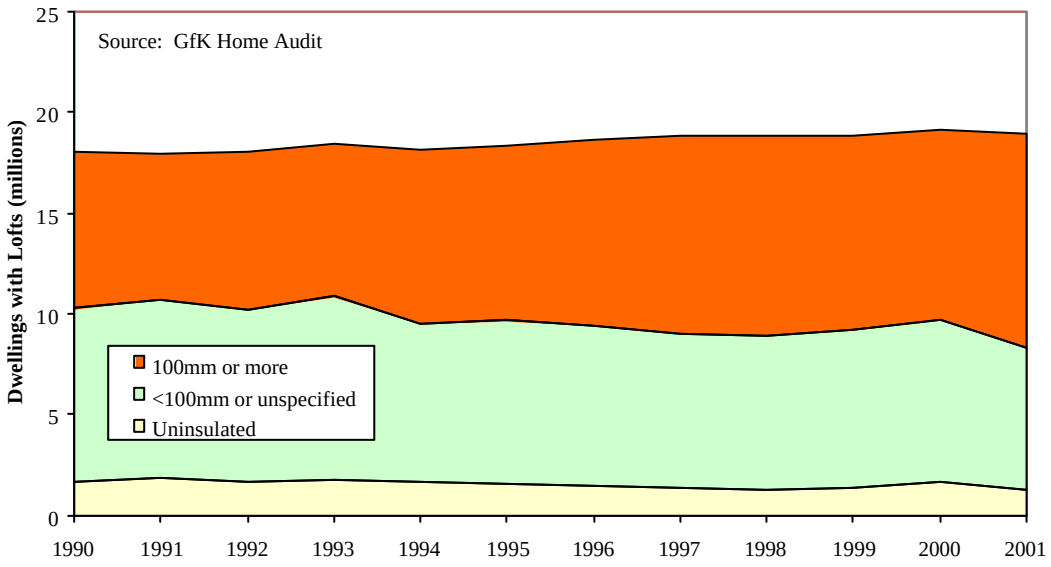
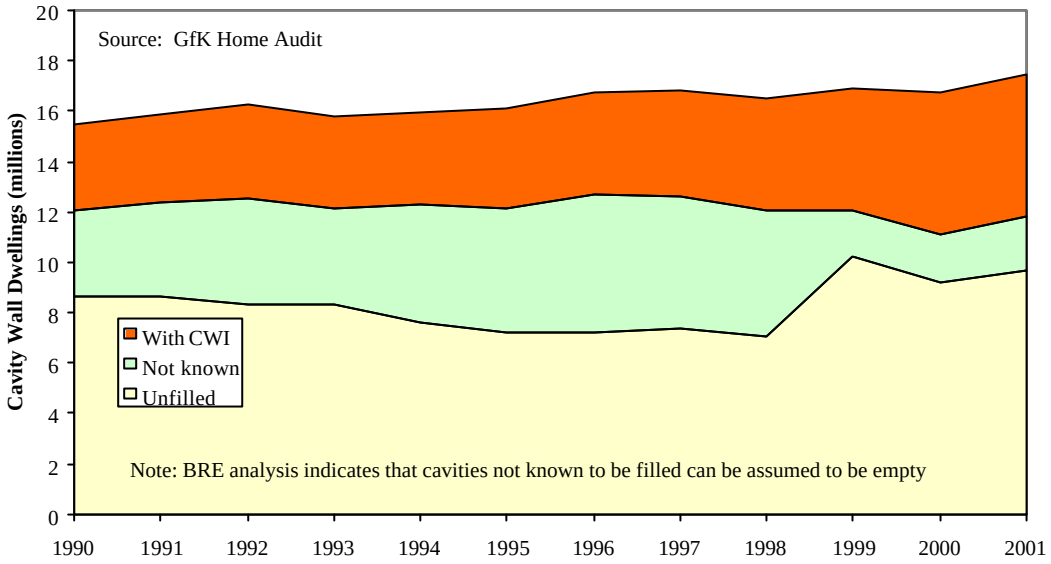
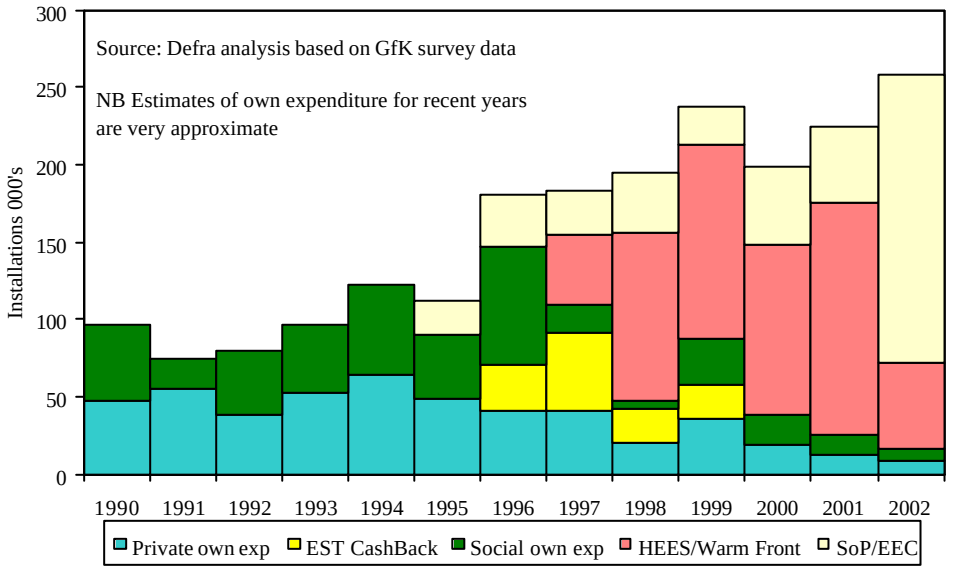


**Figure 9: Ownership of Cavity Wall Insulation**




19. Figure 10 provides an approximate analysis of the sources of funding for cavity wall insulation installations over the period, showing the influence of programmes[12]. The installations attributed to 'own expenditure' are all in addition to programmes.

**Figure 10: Influence of Programmes on Cavity Wall Insulation**




[12] Please note that the CashBack, Standards of Performance (SoP) and Energy Efficiency Commitment (EEC) schemes include significant financial input from both owner occupiers and social housing providers, as well as energy suppliers.

20. Figure 11 illustrates the take-up of central heating, which has made a major contribution to the increase in comfort standards and thence service demand, and Figure 12 shows boiler efficiency improvements in terms of the SEDBUK labelling system.

**Figure 11: Central Heating Ownership and Heating Efficiency**

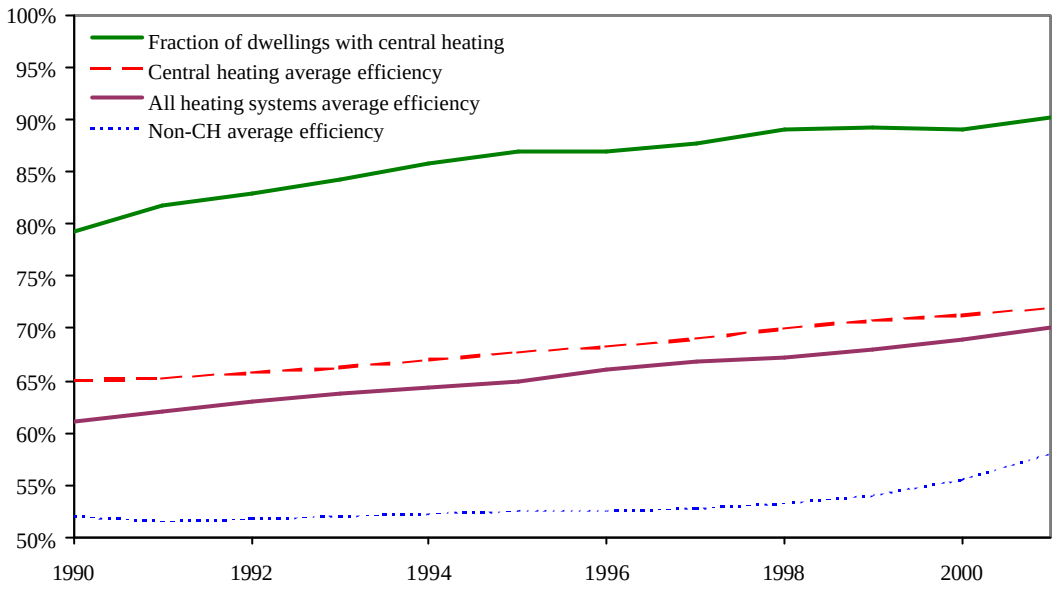
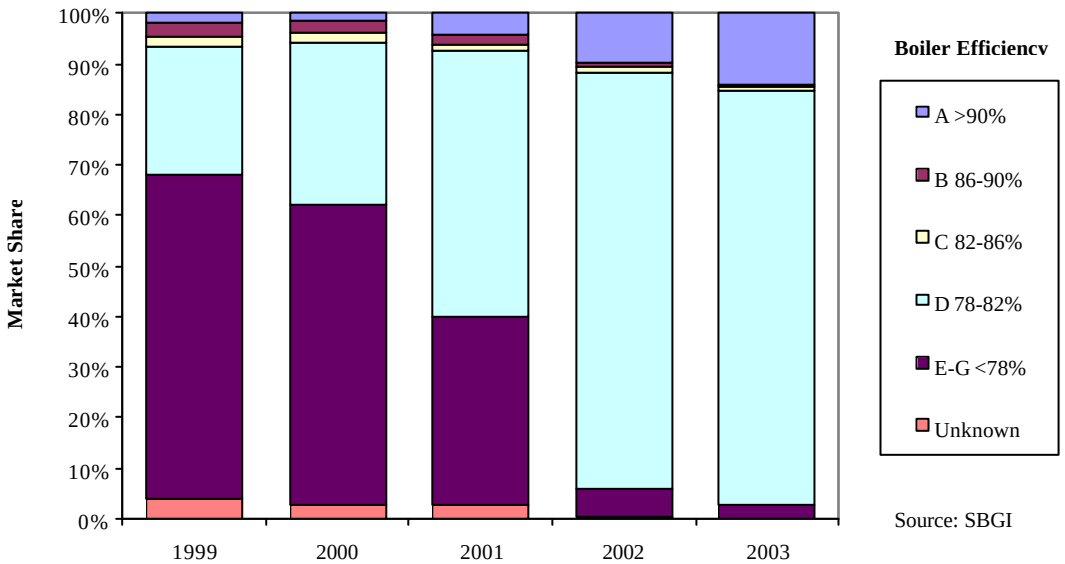



**Figure 12: Household Boiler Sales by SEDBUK Efficiency Band**




Any queries relating to the development of the household sector indicators analysis should be directed to John Collingwood at Defra.

email: john.collingwood@defra.gsi.gov.uk