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an introduction to low carbon domestic refurbishment

construction products association

Foreword

The UK has made a commitment to reduce its carbon dioxide emissions by 80% by 2050 and the built environment is expected to account for about half of this reduction. Programmes are being put in place to ensure that the new buildings we create in the future meet the highest practical and cost effective standards for energy efficiency, but impressive as we expect this achievement to be, it will barely scratch the surface in terms of meeting the contribution that the built environment has to make to the overall carbon reduction target.

The real challenge is to improve the energy efficiency of the buildings that exist today, the vast majority of which will continue to exist in 2050. This will involve some form of refurbishment of each of the 26 million homes and 2 million non-domestic buildings – a programme that it is estimated will cost at least £500 billion over the next forty years. The scale of such a programme is unprecedented in both the challenge and opportunity it provides for the construction industry.

This Introduction to Low Carbon Domestic Refurbishment sets out the various ways in which homes can be upgraded. It begins with first principles and highlights what needs to be done before work starts, then focuses on the main elements of the home – the floor, walls, windows and roof, and the ventilation, heating, hot water, lighting and electrical systems. It concludes with a series of case studies that show the different scale of activity that can be undertaken, ranging from low cost work on walls, lofts and floors, through to radical whole-house renovations.

The information is presented in a way that will be of value to a wide audience – the informed householder trying to decide where to start on their property, the builder looking to advise their clients on the most cost effective solution for them, as well as regulators and politicians, who need to understand the challenges ahead.

Every household in the country needs to be engaged in this programme at some point over the next thirty-six years and it is imperative that the work undertaken is carried out in a cost effective and efficient manner, with least inconvenience to the owners and occupiers. Success will require everyone to play their part and understand the balance between costs and benefits.

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The aim of this guide

This guide is intended for builders who are carrying out refurbishment of existing houses and flats. It will also be of interest to householders who are planning to refurbish their homes, their professional advisors (architects, surveyors and energy consultants), politicians and regulators. The aim of the guide is to provide clear information about how to refurbish in a way that improves the energy efficiency of the building and therefore reduces carbon dioxide emissions from energy use for heating, hot water, lighting and domestic appliances. We deal first with basic principles and the preliminary considerations associated with planning a refurbishment project and then with each of the elements of a house (floors, walls, heating system) in turn. Each section of the guide includes references and links to sources of more detailed information. The case studies at the end of the guide provide examples of a variety of low carbon refurbishment projects.

Climate change

Climate change brought about by man-made emissions of greenhouse gases has been identified as the greatest challenge facing human society during the twenty-first century. In the UK, each person's share of our national greenhouse gas emissions is around ten tonnes per year. Stabilising global emissions at a sustainable level will involve reducing emissions to two tonnes per person per year. Every individual, every industry and every profession will have a part to play in meeting the challenge.

The complex mechanisms of climate change involve the balance of greenhouse gases in the atmosphere, in the oceans and in all living things. The main mechanism is the greenhouse effect, by which levels of greenhouse gases in the atmosphere affect the heat balance of the earth. The process is summarised in Figure 1.1.

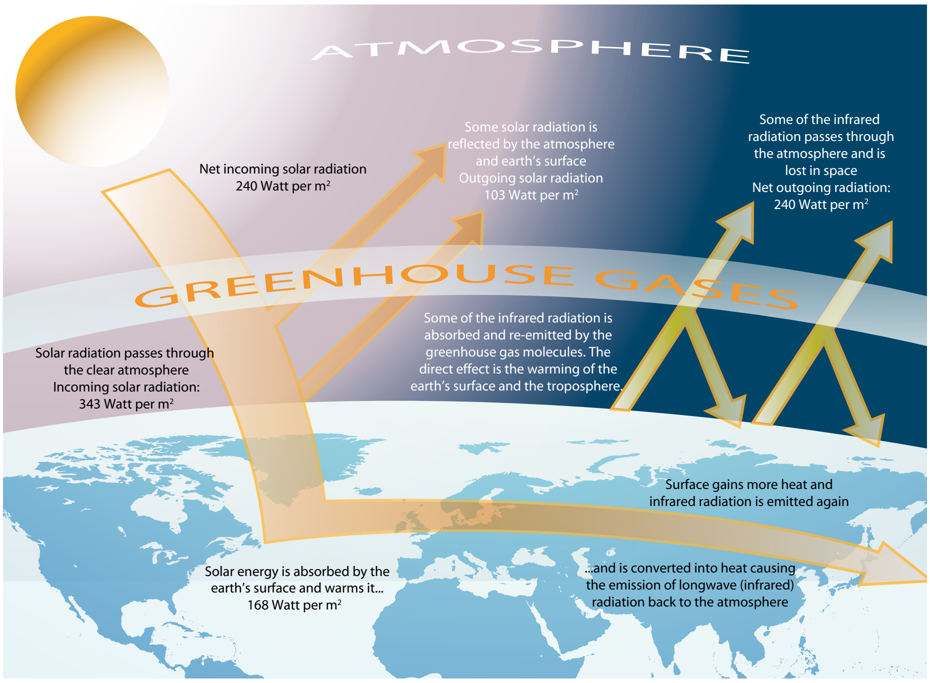

Figure 1.1 The process of global warming caused by greenhouse gases in the atmosphere. Adapted from 'Greenhouse effect', Philippe Rekacewicz, UNEP/GRID-Arendal Maps and Graphics Library. 2005

The principal greenhouse gas is carbon dioxide, which is emitted when we burn fossil fuels including gas, solid fuel (such as coal) and electricity (which is currently generated mostly by burning gas and coal). Table 1.1 shows the carbon dioxide emissions factors for fuels used in the UK, i.e. the amount of carbon dioxide emitted (including power station emissions and emissions associated with processing and distribution) per unit of energy delivered to the building. The third column of the table indicates the relative size of the emissions factors, compared to mains gas. Note that the carbon dioxide emissions associated with the use of grid electricity are more than twice as large as the emissions associated with the use of the same amount of energy in the form of gas.

Fuel	Carbon dioxide emissions factor kgCO_2/kWh	Emissions factor relative to mains gas
Mains gas	0.216	1.00
LPG (bulk)	0.241	1.12
Oil	0.298	1.38
House coal	0.394	1.82
Grid electricity	0.519	2.40
Wood chips	0.016	0.07
Wood pellets	0.039	0.18
Wood logs	0.019	0.09

Table 1.1 Carbon dioxide emission factors for domestic fuels used in the UK (source: SAP 2012, Table 12)

The European Union has adopted a policy to reduce carbon dioxide emissions by 20% and to obtain 20% of energy from renewable sources such as wind power and solar power, throughout the EU, by 2020. The UK government has set a target of reducing carbon dioxide emissions by 80% by 2050, with intermediate targets to be met during the next twenty years. As part of the process of meeting these targets, the government has developed the Green Deal, a mechanism by which householders may borrow the capital required to carry out low carbon refurbishment and repay it via a charge on their electricity bills, over a period of up to twenty years. The annual charge may not exceed the predicted annual fuel cost saving. The charge is attached to the electricity meter, not to the occupant, so when the occupant changes the charge is paid by the new householder. Thus occupants only pay the Green Deal charge while they are enjoying the benefits of the refurbishment. The government has also introduced the Energy Company Obligation (ECO), which obliges large energy retailers to spend approximately £650 million per year for at least four years (collectively) on reducing carbon dioxide emissions from buildings. ECO funding is available for 'hard to treat' homes (e.g. those with solid external walls) and for households in fuel poverty, as well as for community-scale refurbishment projects, but following changes in the autumn of 2013 much of the money seems likely to be spent on cheaper, basic measures such as loft insulation and cavity wall insulation. The government has also introduced a Feed in Tariff (FIT) to provide a financial incentive for the local generation of electricity from renewable sources such as photovoltaics and a Renewable Heat Incentive (RHI) to provide a financial incentive for the local generation of heat and hot water from renewable sources such as solar energy and biomass.

These programmes are just the start of an emerging national refurbishment programme on an unprecedented scale. The refurbishment of over 20 million homes in less than forty years implies that on average we must improve at least half a million homes every year – a rate of nearly one every minute! At an average cost of £25,000 per dwelling the domestic refurbishment programme will have a value of approximately £500 billion, presenting not only a funding challenge for all involved but also a significant business opportunity for the construction industry. Already, local authorities are promoting low carbon refurbishment through regional partnerships with industry such as Birmingham Energy Savers and Warm Up North. We can expect to see many similar schemes during the coming years.

Energy use in our homes

Carbon dioxide emissions associated with all energy use in the UK amount to more than 500 million tonnes each year (the exact amount depends on the weather). Almost half of these emissions are associated with energy use in buildings. Energy use in housing accounts for slightly more than half of the emissions associated with energy use in all buildings, amounting to 28% of the UK total – typically between 135 million and 150 million tonnes per year. Despite measures to improve the energy efficiency of dwellings, carbon dioxide emissions are rising, mostly because of a significant increase in the numbers of electrical appliances in homes. Increasing household numbers and a tendency to heat our properties to higher temperatures are also contributing to rising emissions.

There are approximately 26 million homes in the UK. The stock has grown from 18 million in 1976 and is expected to reach 27 million by 2020 – 50% growth in less than fifty years. From 2016 new dwellings will have to be 'zero carbon', but few new dwellings will replace existing ones; the average replacement rate of the housing stock, during the last fifty years, has been less than 1% per year. Because of this, in any one year, only 0.3% of carbon dioxide emissions are associated with the new homes built that year and 99.7% of emissions are associated with dwellings built in previous years. Over 80% of the current stock of homes will still be standing and occupied in 2050. Therefore the required 80% reduction in emissions associated with energy use in housing cannot be achieved without significant improvement in the energy efficiency of existing homes.

Since we refurbish our homes only rarely (at intervals of twenty or thirty years), it is important to seize every opportunity to improve energy efficiency. If you are improving your home, you should incorporate measures to improve its energy efficiency and reduce the carbon dioxide emissions associated with energy use. If you are advising homeowners on refurbishment projects, you should advise them to improve energy efficiency as much as possible. In an era of rising fuel prices this is sound advice, irrespective of the argument for reducing emissions. Benefits for homeowners include lower fuel bills and improved comfort, as well as helping to meet the challenge of climate change.

The energy efficiency of existing dwellings and their potential for improvement depends largely on their age. Before the 1930s, most buildings were built with solid brick walls, which are relatively expensive to insulate, and with single glazed windows and solid fuel heating. Since the 1930s most domestic buildings have been built with cavity walls, which are easy to insulate by filling the cavities; to date, approximately 40% of the originally empty cavity walls have been insulated. Roofs have been progressively improved since the 1970s by the installation of loft insulation. Since the 1960s, single glazed windows have slowly been replaced by new double glazed windows.

Gas-fired central heating is installed in nearly 90% of dwellings, but a significant number of dwellings have no gas supply. Boilers are replaced at 10-20 year intervals; and boiler efficiencies have increased, from 65% or less in the 1970s to around 90% for new condensing boilers today.

From 1976, regular improvements in the energy efficiency of new dwellings have been driven by the Building Regulations. Insulation standards were increased in 1982, 1990, 2002, 2006, 2010 and 2014. Overall energy efficiency standards for dwellings were first introduced in 1995 and increased in 2002, 2006, 2010 and 2014. Further changes are planned for 2016.

Today, an average 1930s semi-detached house of 90 m^2 floor area, with some insulation and gas-fired central heating, uses approximately 26,000 kWh of energy per year for heating, hot water, cooking, lighting and appliances. Fuel costs are approximately £4,100 per year (including 5% VAT) and carbon dioxide emissions are approximately six tonnes per year, of which 70% are associated with fossil fuel use (mostly for heating and hot

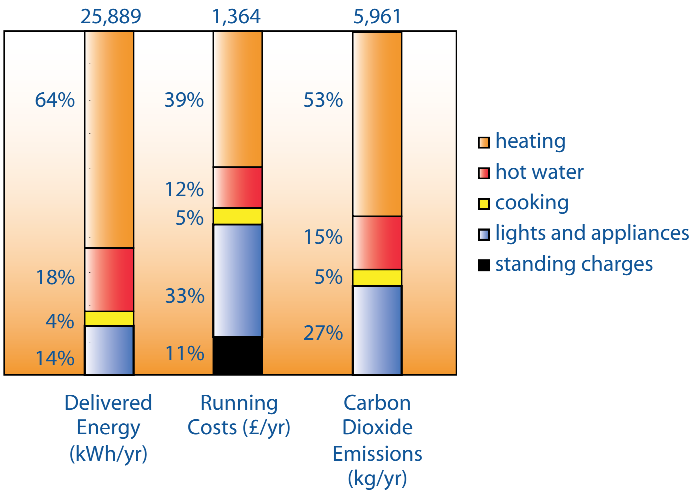

Figure 1.2 The breakdown of annual fuel use, fuel costs and carbon dioxide emissions for a typical 1930s semi-detached house of 90 m² floor area

water) and 30% are associated with electricity use.

Figure 1.2 shows the breakdown of annual fuel use, fuel costs and carbon dioxide emissions for this typical house.[1]

Energy standards for refurbishment

In this guide, we have adopted two energy standards for housing refurbishment: a current 'good practice' standard, and an 'advanced' or 'low carbon' standard. These standards may be applied to individual elements (e.g. exposed floors, walls and roofs, heating systems) and to the dwelling as a whole:

- The good practice standard exceeds the current minimum standards required by the Building Regulations[2], and is consistent with guidance published by the Energy Saving Trust[3]. This standard is readily achievable using widely available materials and products with which builders and installers are familiar

- The advanced standard is the 'EnerPHit' standard developed by the Passive House Institute, which aims to reduce overall carbon dioxide emissions by 60% or more. Refurbishing a home to this standard will be more complicated and expensive, but will often be a more appropriate response to the challenge of climate change, especially if another improvement opportunity may not arise (or may not be affordable) for some time

Refurbishment strategies: the three-stage approach

There are two common approaches to improving the energy efficiency of a home during refurbishment: the 'measures-based' approach and the 'whole-house' approach:

- The measures-based approach involves the installation of individual improvement measures one-by-one at different times. Measures such as cavity wall insulation, loft insulation, new windows or a more efficient boiler are chosen because opportunities arise – for example, the offer of grant funding or the need to replace worn out window frames or a broken boiler

- The whole-house approach involves installing a 'package' of improvement measures embracing the building fabric (exposed floors, walls and roofs, and heating systems), the building services (heating, hot water, ventilation and lighting) and often renewable energy systems (e.g. solar water heating) at the same time

1 All of the figures quoted in this paragraph and presented in Figure 1.2 were calculated under SAP standard occupancy using BREDEM-12 based NHER Plan Assessor (SAP 2005) version 4.5 software.

2 See Building Regulations Approved Document L1B, 'Conservation of fuel and power in existing dwellings' (2013 edition), NBS.

3 For the Energy Saving Trust's online guidance see www.est.org.uk.

The measures-based approach has been adopted for many government-funded programmes such as the Energy Company Obligation (ECO) that obliges energy suppliers to reduce emissions associated with energy use by their customers. This approach is straightforward and affordable and minimises disruption of the household during installation, but it takes a long time and a lot of projects to achieve significant reductions in carbon dioxide emissions.

When a major refurbishment is being carried out, the whole-house approach should be adopted. This approach is often more expensive and disruptive, but it allows most of the work to be completed at once so that significant fuel cost savings and emissions reductions are obtained immediately.

In reality, few households can afford to adopt the whole-house approach, and many are unwilling to undertake work that may involve them moving out of their home while improvements such as internal wall insulation, floor insulation or whole-house ventilation are installed. Nevertheless, the challenge of climate change is significantly to improve the energy efficiency of most of our homes within the next forty years and there are at least 20 million dwellings to improve.

Therefore in this guide we recommend a three-stage approach, which involves having a plan for the dwelling (see Chapter 2) and implementing it progressively, as opportunities arise and funding becomes available, perhaps over many years. The three stages are as follows:

1 **Make 'quick fixes':** Improvement measures that are affordable, achievable with readily available materials and products by existing installers, and not too disruptive

2 **Exploit and preserve opportunities:** Options for improvement often arise while other work is being carried out. It is essential to exploit these opportunities because they may not arise again for some time. It is also important not to close down options for making improvements in the future. For example, it makes sense to insulate the roof when re-roofing and to replace windows when installing wall insulation. If external wall insulation is planned as a future improvement, it may be appropriate to allow for it by extending the eaves when re-roofing. If a hot water cylinder is replaced, it may be appropriate to specify a twin-coil cylinder ready for the later installation of solar water heating

   The Building Regulations require us to exploit some improvement opportunities: for example there are minimum efficiencies for replacement boilers and if you re-plaster or re-render more than a certain percentage of any external wall you must insulate the whole wall[4]. The Building Regulations are dealt with in more detail in Chapter 3.

4 See the guidance in Building Regulations Approved Document L1B, 'Conservation of fuel and power in existing dwellings' (2013 edition), NBS.

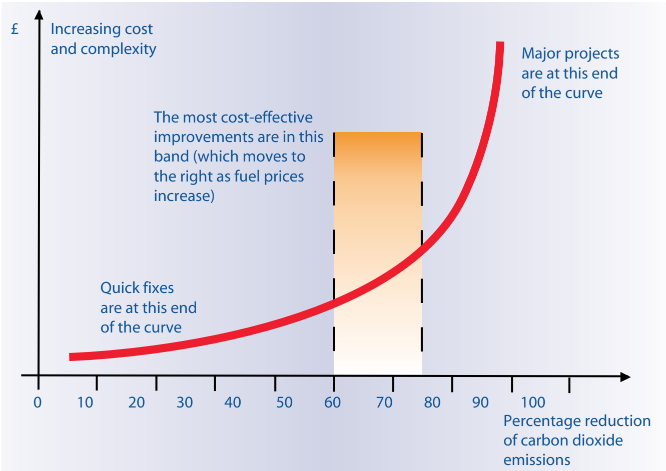

Figure 1.3 How the cost and complexity of refurbishment varies with emissions reduction

3 **Implement major projects:** Eventually, if we are to meet our national emissions reduction targets, major improvements to most homes are likely to be required. These are often best implemented when carrying out other work (replacing a kitchen or bathroom or having a loft converted), when funding becomes available, or before moving into a house for the first time

We will return to this three-stage process in Chapter 3.

The capital cost of a refurbishment project designed to reduce carbon dioxide emissions increases exponentially with the percentage by which emissions are to be reduced, as shown in Figure 1.3. The average capital cost of reducing emissions by 80% or more may be more than £50,000. A more practical target of reducing emissions by between 50% and 60% may cost only half as much. 'Quick fixes' (stage 1) lie along the left-hand end of the curve. Exploiting and preserving opportunities (stage 2) reduces the cost and disruption associated with some projects, making them more affordable. Major projects (stage 3) lie at the middle and towards the top of the curve.