RIBA

Climate Change Briefing

Cover image National Assembly for Wales, Rogers Stirk Harbour & Partners. Debating chamber natural ventilation funnel with mirrored reflector. Sustainable strategies and renewable energy systems were implemented throughout the building.
Photo Richard Bryant/Arcaid.co.uk

About this Document

This is the first of six components of Climate Change Tools, a package of guidance developed by the RIBA to encourage architects to engage with the issue of climate change and to deliver low-carbon new buildings and low-carbon refurbishment of existing buildings.

This ***Climate Change Briefing*** sets the scene; the other elements of this package of guidance are:

- A ***Carbon Literacy Briefing***, about the carbon dioxide emissions associated with energy use in buildings
- *Principles of Low Carbon Design and Refurbishment*
- *Low Carbon Standards and Assessment Methods*
- *Low Carbon Design Tools*
- *Low Carbon Skills and Training*

Each guide summarises its subject and provides links to other sources of more detailed information.

Introduction

Climate change brought about by man-made emissions of greenhouse gases has been identified as the greatest challenge facing human society at the beginning of the twenty-first century.

The United Nations Intergovernmental Panel on Climate Change (IPCC) has suggested that human society could eventually be reduced to a few isolated groups eking out an existence near the poles. Even though this scenario may seem implausible, we must all consider the potential consequences of not taking action to mitigate the risk.

'We are currently in a twilight war against climate change; we have identified the enemy, we are marshalling our forces and we are skirmishing. But within 15 years we will be in all out war against climate change and it will influence everything we do.'
Colin Challen, MP, Chair – All Party Parliamentary Climate Change Group

Every individual, every industry and every profession will have a part to play in meeting the challenge.

Each person in the UK is responsible for around 10 tonnes of greenhouse gas emissions per year. Stabilising global greenhouse gas (GHG) emissions at a sustainable level would involve reducing UK GHG emissions to two tonnes per person per year.

This briefing:

- Explains the basic mechanisms and likely effects of climate change
- Summarises international and UK GHG emissions reductions targets
- Explains the contribution of buildings to the UK's national GHG emissions, and the effect of growth and replacement rates
- Sets out the RIBA's key climate change policies and its expectations of members for the buildings that they design and specify.

The Mechanisms of Climate Change

The Greenhouse Effect

The complex mechanisms of climate change involve the balance of carbon 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.

Of the radiation from the sun arriving at the earth, approximately 30% is reflected by the atmosphere or by the earth's surface. The radiation that is absorbed by the earth's surface warms it, supporting life. In doing so, this radiation is converted into heat, causing the emission of longwave radiation from the earth into the atmosphere. Some of this radiation passes through the atmosphere

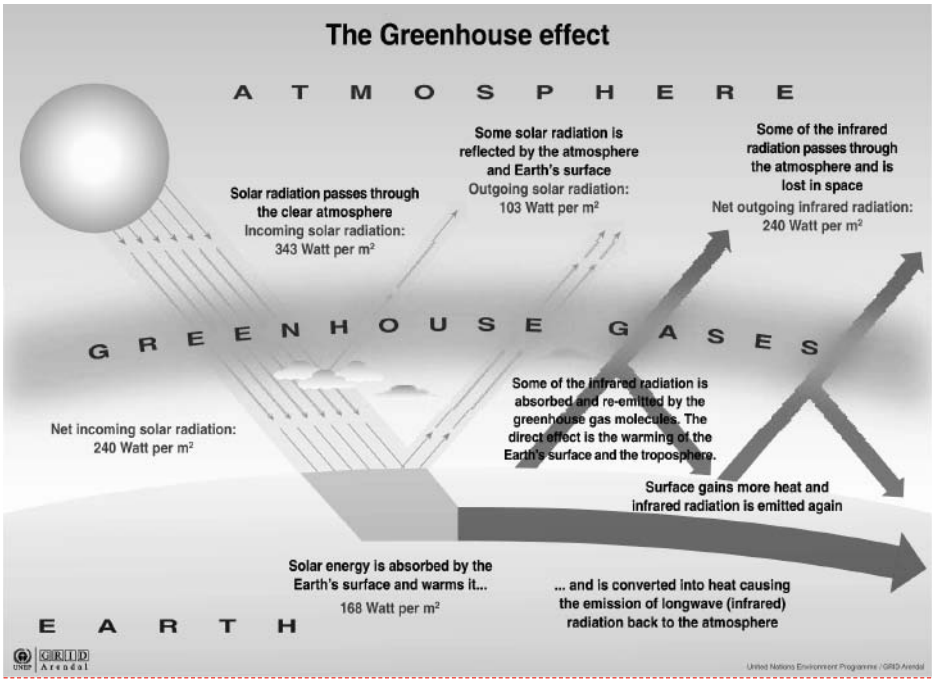

Figure 1 The mechanism of global warming. Source: Okanagan University College, University of Oxford, EPA, IPCC, Philippe Rekacewicz

and is lost in space; the remainder is trapped by greenhouse gas molecules, warming the atmosphere and the earth's surface and causing more longwave radiation.

The major greenhouse gases are carbon dioxide, nitrous oxide and methane. As the concentration of greenhouse gases in the atmosphere increases, more longwave infrared radiation from the earth's surface is absorbed, further warming both the atmosphere and the earth's surface.

Global temperatures are rising because of the increasing concentration of greenhouse gases, particularly carbon dioxide, in the atmosphere.

The concentration of carbon dioxide in the atmosphere increased from approximately 280 parts per million by volume in the pre-industrial era to 380 parts per million in 2007. It is projected to increase to over 500 parts per million by 2050.

Global Temperatures

Figure 2 illustrates the trend in global average surface temperature since 1860. The significant increase in temperatures during the century is attributed primarily to the burning of fossil fuels, releasing carbon that has been locked into the earth's crust for millions of years.

There is an overwhelming scientific consensus that climate change is taking place as a consequence of man-made greenhouse gas emissions. Many of our day to day activities create emissions of greenhouse gases – running our buildings, travelling, extracting resources, manufacturing products.

A recent report by the IPCC confirms that global greenhouse gas emissions increased by 70% and carbon dioxide emissions by 80% between 1970 and 2004, in line with world-wide economic growth, and predicts that emissions will continue to increase over the next several decades[1].

Feedback Effects

There are some damping mechanisms in the natural carbon cycle: for example, when there is more carbon dioxide in the atmosphere, more of it dissolves in the oceans. Also, as temperatures rise, trees grow faster, converting more atmospheric carbon dioxide into solid carbon (wood).

However, another consequence of the warming process appears to be the melting of glaciers and polar ice caps. This reduces the reflectivity of the earth, increasing the proportion of incoming solar radiation that is absorbed into the earth's surface, re-radiated as longwave radiation and then trapped by greenhouse gases in the atmosphere. Some scientists believe that this positive feedback process may lead to runaway warming, resulting in catastrophic climate change.

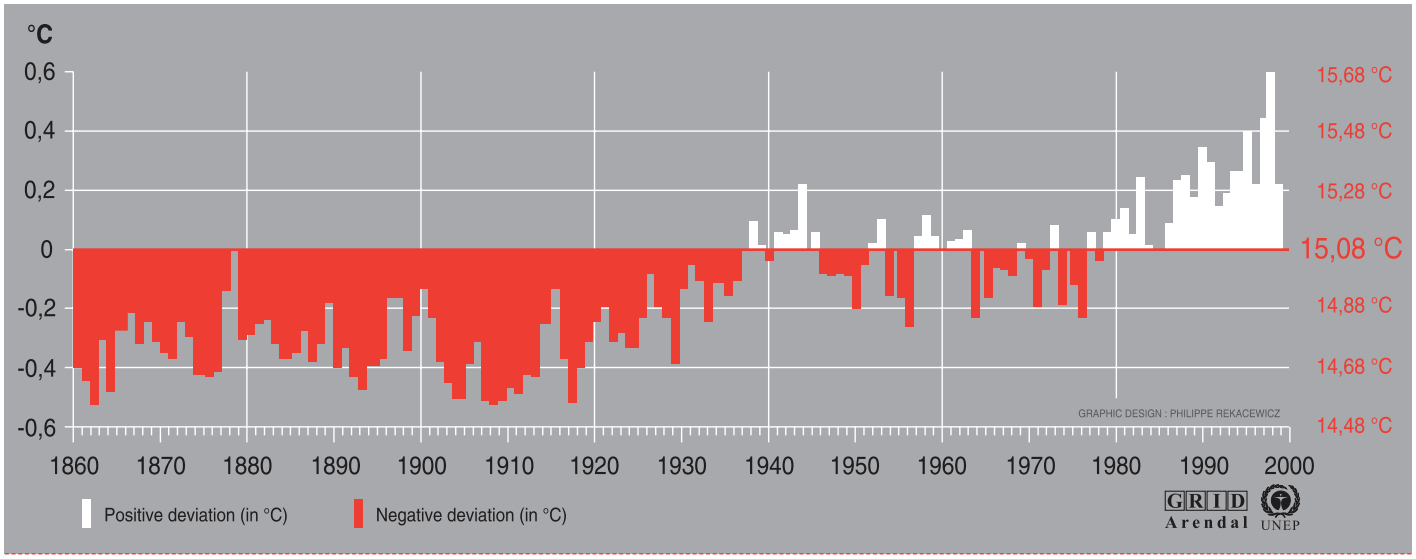

Figure 2 The trend in global average temperatures since 1860. Source: School of Environmnetal Sciences, Climatic Research Unit, University of East Anglia, UK, 1999

1 *Climate Change 2007: Mitigation of Climate Change*, Working Group III Contribution to the Fourth IPCC Assessment Report, UNIPCC, 2007

The Effects of Climate Change

The effects of climate change are complex. They include:

- Increased average temperatures
- Rising sea levels (because of the melting of glaciers and of polar ice caps)
- Increased precipitation
- More frequent extreme weather events.

Figure 3 illustrates the possible secondary effects of climate change, including impacts on human health, agriculture, forestry, water resources, coastal areas and species and their habitats.

The effect on human society is also likely to be significant; a recent report *The Economics of Climate Change*[2] (also known as the *Stern Review*) considered the economic costs and impacts of climate change and the costs and benefits of action to reduce greenhouse gas emissions. The *Stern Review* concluded that the benefits of strong, early action considerably outweigh the costs:

'Climate change presents a unique challenge for economics: it is the greatest and widest ranging market failure ever seen. The evidence shows that ignoring climate change will eventually damage economic growth. Our actions over the coming few decades could create risks of major disruption to economic and social activity, later in this century and the next, on a scale similar to those associated with the great wars and the economic depression of the first half of the twentieth century...

Tackling climate change is the pro-growth strategy for the longer term. The earlier effective action is taken, the less costly it will be. At the same time, given that climate change is happening, measures to help people adapt to it are essential. The less mitigation we do now, the greater the difficulty of continuing to adapt in the future.'

UK after Climate Change?

Rising sea levels are a particular danger: some scientists predict that much low-lying land could be flooded during this century, including entire countries such as Bangladesh, some island nations and many of the world's coastal cities. The scientific consensus suggests that sea levels may rise by 1-3 metres this century, but some estimates predict much greater rises, possibly as much as 50 metres. The map above shows the impact of a 10 metre rise in sea levels across the UK.

Source: Geomantics

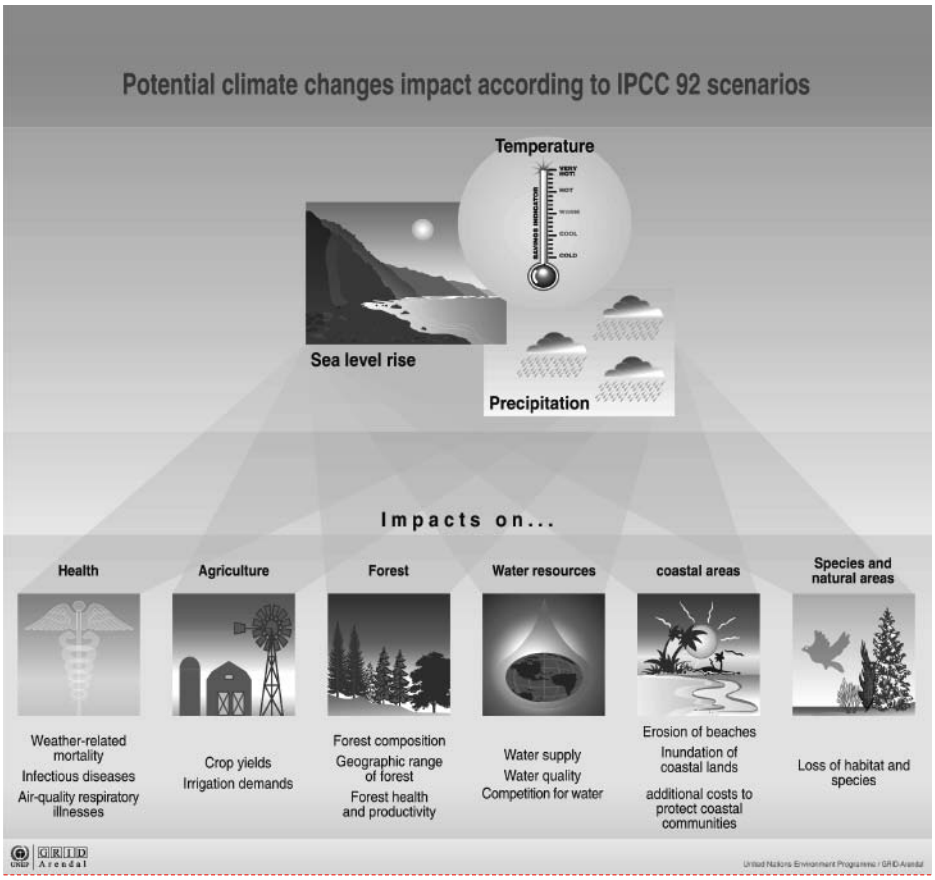

Figure 3 Source: United States Environmental Protection Agency (EPA), Philippe Rekacewicz

2 Stern Review: *The Economics of Climate Change*, Cambridge University Press, 2007

Political Action to Address Climate Change

Mitigation and Adaptation

Action to address climate change falls into two categories: mitigation policies are designed to reduce greenhouse gas emissions to slow down or stop climate change; adaptation policies are designed to adjust society to cope with climate changes that are already happening or are likely consequences of current GHG emissions.

Contract and Converge

One approach to reducing GHG emissions, as recommended by climate change scientists including the IPCC, is known as 'contraction and convergence'. This involves emissions from industrialised nations reducing (contracting) and emissions from all nations converging to an overall target. The target would be set to stabilise emissions at a sustainable level, and the convergence process would promote equitable distribution of the benefits associated with the energy use giving rise to the emissions. To achieve this equitable distribution, each of us in the UK would need to reduce our average annual carbon dioxide emissions from 10 tonnes to two tonnes.

The Kyoto Protocol

So far, the focus of international action to mitigate climate change has been the Kyoto Protocol, a binding international treaty ratified by many nations (but not by the United States of America, or Australia). This treaty sets short-term GHG emissions reduction targets for industrialised nations. These targets were negotiated after the Climate Change Summit in Rio de Janeiro in 1990, starting from the IPCC's early recommendation that in order to avoid catastrophic climate change, emissions from industrialised nations should be reduced by 60% (based on 1990 levels) by 2050. The Kyoto Protocol expires in 2012, and negotiation of a successor agreement is currently in hand (2007).

European Strategy

The European Union's response to climate change is being co-ordinated via the European Commission.

There are Europe-wide standards for energy efficiency in many areas, for example, motor vehicles and office equipment.

The European Union Emissions Trading Scheme (EUETS) is intended to reduce emissions associated with energy use by commercial organisations and public bodies. Organisations with low emissions (below government-set quotas) can sell emissions 'credits' to organisations with emissions above their quota. A variant of emissions trading is carbon offsetting, whereby individuals or organisations invest in GHG emissions reduction schemes to cancel out their own emissions. Investments are often made in forestry or renewable energy generation projects. However, many offsetting schemes have been criticised because emissions reductions have proved difficult to verify. It is also not clear whether offsetting just cancels out growth in emissions, rather than delivering real cuts in greenhouse gases.

Several mandatory European Directives promote energy efficiency and the reduction of GHG emissions; perhaps the best known of these (in the building and housing industries) are the European Directive on the Energy Performance of Buildings (EPBD) and the Energy Services Directive (ESD).

The EPBD is being implemented across the European Union between January 2006 and January 2009. The EPBD promotes energy efficiency in all buildings (new and existing, domestic and non-domestic) through:

- The establishment of national or regional performance calculation methodologies and energy performance standards for buildings
- Certification of the energy performance of buildings when they are first occupied and when they are subsequently sold or rented out
- Regular checks on the efficiency of building services plant.

More Information about the Effects of Climate Change

You can find out more about the impact of climate change in the UK from the UK Climate Impacts Programme (www.ukcip.org.uk).

The World Business Council on Sustainable Development has published wide-ranging information about these issues in its *Energy and Climate Change* series of reports (see www.wbcsd.org).

The ESD must be implemented in all EU member States by May 2008. The ESD sets a national indicative energy saving target of 9% by 2017, requires the public sector to fulfil an exemplary role in meeting the target, places obligations on energy suppliers and distributors to promote energy efficiency, and promotes energy metering and billing arrangements that allow consumers to make better informed decisions about their energy use.

UK Targets

The UK's national target under the Kyoto Protocol is to reduce GHG emissions by 12.5% (based on 1990 levels) by sometime between 2008 and 2012. The Government is on course to meet this target, largely as a result of reductions in emissions associated with the energy supply industry.

In addition to its international obligations under the Kyoto Protocol, the UK Government in 1997 adopted a voluntary target to reduce GHG emissions by 20% (based on 1990 levels) by 2010. The Government recently confirmed that it is not on course to meet this target.

The Energy White Papers in 2003 and 2007 established an 'aspirational' target:

'to put ourselves on the path to cut the UK's carbon dioxide emissions by some 60% by about 2050, with real progress by 2020.'

This has become known as the 'carbon 60' (or C60) target.

Some climate change scientists now suggest that deeper cuts in GHG emissions will be required before 2050.

The UK Climate Change Programme

The UK Government's strategy for dealing with climate change continues to develop[3]. It embraces polices both for mitigating climate change (i.e. reducing GHG emissions) and for adapting to the effects of climate change. The strategy is cross-departmental and addresses most of the sectors of national life that give rise to GHG emissions: industry (including the energy industries); public services; transport and buildings (domestic and non-domestic). Organisations in most sectors have been put under some degree of pressure (either via regulatory standards or financial incentives) to reduce emissions. Key features include:

- The Building Regulations Part L, which are designed both to mitigate climate change by reducing GHG emissions associated with energy use in buildings and to adapt building practice to the consequences of climate change. They impose minimum standards of energy efficiency for new buildings and for existing buildings when they are altered or extended. Planned changes to Part L1 are designed to reduce energy use in new dwellings by 25% from 2010 and by 44% from 2013 (relative to 2006 standards). New dwellings will be expected to be zero carbon by 2016[4]. A zero carbon home is defined as one with zero net emissions of carbon dioxide from all energy use in the home including appliances.
- The Code for Sustainable Homes, which sets broad environmental performance standards, including energy efficiency, for new housing. It establishes six performance 'levels', the most exacting of which (Levels 4, 5 and 6) are consistent in energy terms with the planned Building Regulations outlined above. All new publicly funded housing must achieve at least Level 3 of the Code. Consideration is being given to making assessment against the Code mandatory (although not achievement of any particular Level).
- The Climate Change Levy imposed on business energy users. This is essentially a tax on fossil fuel use, which can be offset by tax credits for industries that adopt emissions reduction programmes.

3 *Climate Change: The UK Programme*, HM Government, 2006

4 *Building Regulations: Energy Efficiency Requirements for New Dwellings – A Forward Look at what Standards may be in 2010 and 2013*, Department for Communities and Local Government, 2007

- The **Carbon Emissions Reduction Target (CERT)**, which places an obligation on energy suppliers to invest in measures to reduce greenhouse gas emissions associated with energy in domestic buildings.
- The **Warm Front** programme in England (and comparable programmes elsewhere in the UK), which reduces GHG emissions and tackles fuel poverty by means of free or subsidised improvements to the energy efficiency of homes occupied by low-income households.
- The **Low Carbon Buildings Programme**, which provides grant support for the integration of renewable energy technologies into new and existing buildings.
- The **Carbon Trust**, funded by Government, which promotes energy efficiency in industry, the public sector and non-domestic buildings.
- The **Energy Saving Trust**, also Government-funded, which promotes energy efficiency in households and in transport. Its Best Practice Standards identify high standards of energy efficiency in new dwellings and have been incorporated into the Code for Sustainable Homes.

Greenhouse Gas Emissions in the UK

Figure 4 shows total UK GHG emissions for the period since 1990 and projected up to 2020, in relation to the UK's Kyoto Protocol target.

Figure 4 UK GHG emissions, 1990-2020. Source: DTI

Figure 5 shows UK carbon dioxide emissions broken down by source for the same period (1990-2020). Note that under the 'high' estimate, emissions will be higher in 2020 than they are at present.

Both figures record a fall in emissions during the 1990s; this is largely attributed to the 'dash for gas' – a change from coal-fired to gas-fired electricity generation.

Although the graphs suggest that GHG emissions are being reduced, measures to cut emissions are being inhibited (and in some cases cancelled out) by growth in economic activity, and associated growth in the number of dwellings, the amount of industrial and commercial floorspace, the number of vehicles etc.

The Government's current projections suggest that in the absence of action beyond the current Climate Change Programme, carbon dioxide emissions will rise after 2020 and, by 2050, will be at a level higher than today and similar to 1990.

The Contribution of Buildings to Greenhouse Gas Emissions

In 2003, carbon dioxide emissions associated with energy use in the UK were approximately 560 million tonnes. Almost half of this came from 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 27% of the UK total.

Housing

There are approximately 25 million domestic buildings 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 50 years.

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 and electronic appliances in homes. Increasing household numbers and a tendency to heat our properties to higher temperatures are also contributing to rising emissions.

Carbon Dioxide Emissions from Our Homes

Average emissions per dwelling are around six tonnes of carbon dioxide per year.

A new dwelling built to modern standards will produce around three tonnes of carbon dioxide emissions per year.

A large, uninsulated, inefficiently heated dwelling could produce over 40 tonnes per year.

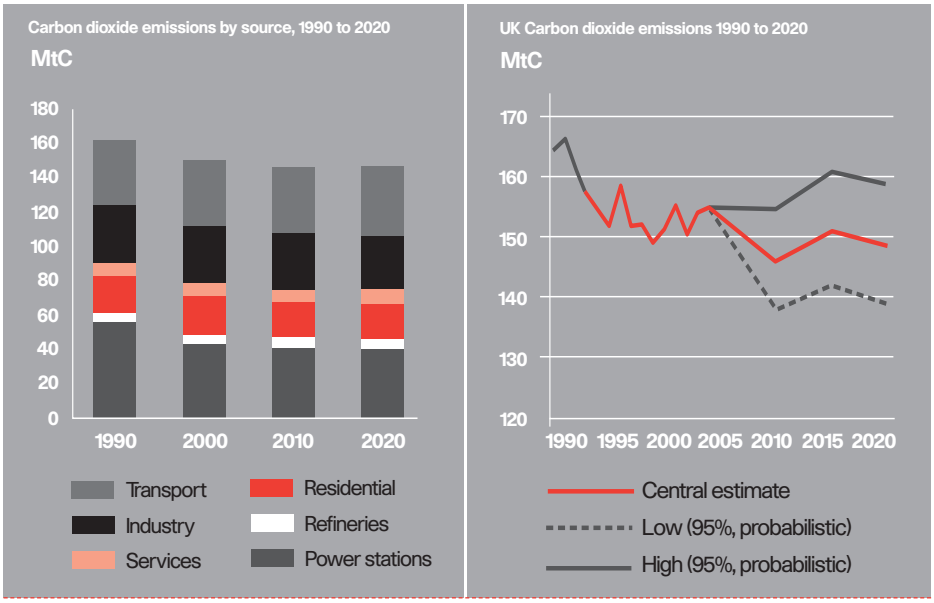

Figure 5 UK carbon dioxide emissions, 1990-2020, in millions of tonnes of carbon (MtC). Source: Defra

Figure 6 suggests the extent of emissions reductions that is likely to be required from the housing stock.

Emissions reductions on the scale suggested by Figure 6 are likely to require:

- Insulation of all unfilled external cavity walls
- Insulation of all lofts with 300 mm thick mineral fibre or equivalent
- Insulation of 15% of solid walls
- Installation of high performance windows throughout the stock
- Installation of, on average, two low or zero carbon technologies in every dwelling. These could include solar water heating, solar photovoltaics or micro-CHP.

In practice, progress towards a 60% reduction by 2050 is unlikely to be a straight line, as shown in Figure 6. The improvement may start slowly and gather pace.

New Homes

Figure 7 shows the estimated cumulative carbon dioxide emissions from new homes between 2005 and 2050, assuming no improvement in energy efficiency above current standards.

Without improvements, growth in the housing stock could increase carbon dioxide emissions by seven million tonnes by 2050 (which is the target date for a 60% reduction). In response to this, Government's current Building Regulations strategy involves plans to reduce the carbon dioxide emissions of new dwellings to zero by 2016[5]. The implications of this challenging target – which covers all energy uses, including electrical and electronic goods – are still being worked out and are likely to present creative challenges to architects.

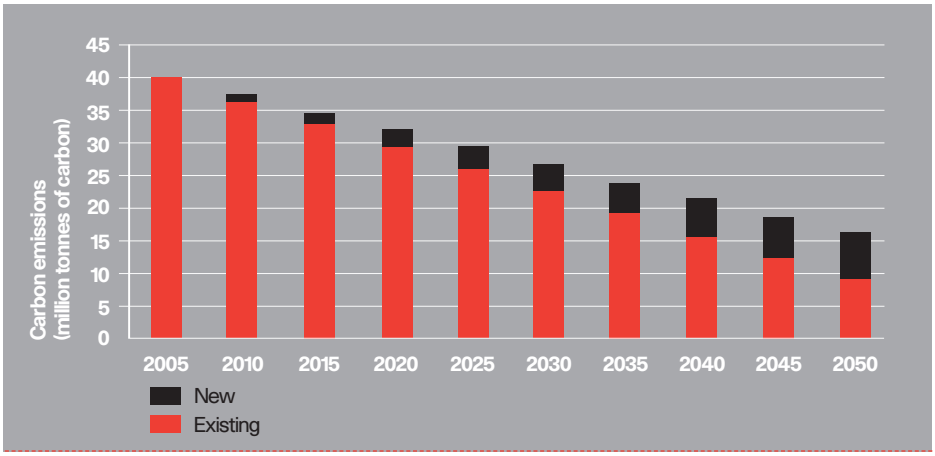

Figure 6 The extent of carbon emissions reductions required from the domestic building stock in order to achieve the C60 target. Source: Energy Saving Trust

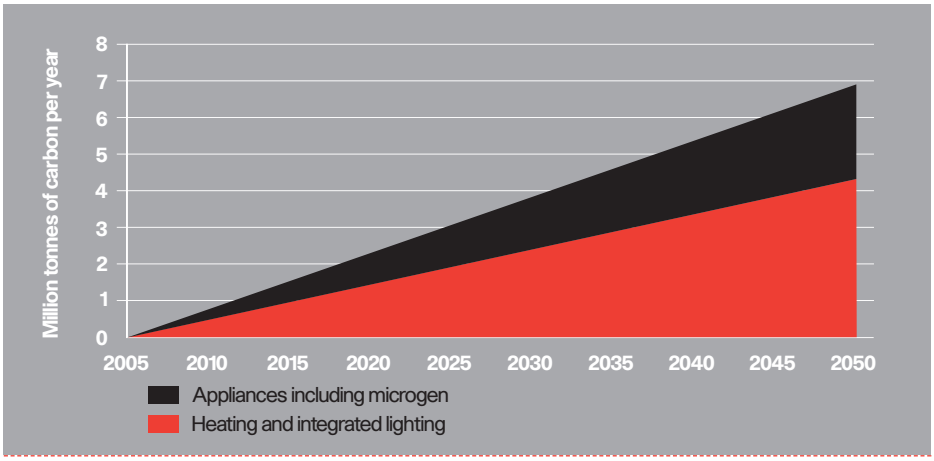

Figure 7 Projected cumulative carbon emissions from new dwellings 2005-2050. Source: Energy Saving Trust

5 The target for new dwellings in 2016 is net zero carbon dioxide emissions associated with energy use; this will permit the use of some fossil fuels provided that the dwellings export sufficient energy from on-site renewable sources to displace equivalent emissions associated with energy use elsewhere.

Existing Homes

The replacement rate of the existing domestic stock is less than 1% per year. Emissions from the existing stock dominate – accounting for 99.7% of the total, whereas new dwellings contribute approximately 0.3% of carbon dioxide emissions.

At the current rate of turnover of the stock, 80% of the dwellings that exist today will still exist in 2050; or, to put it another way, two thirds of the dwellings standing in 2050 already exist[6]. This means it is impossible for the UK to meet its carbon emissions reduction targets without an extensive programme of improvements to the energy efficiency of existing dwellings.

There may also be an increase in the rate of replacement, as existing dwellings that are most costly or difficult to improve are identified.

A side effect of improving the energy efficiency of dwellings in the context of rising temperatures is the potential increase in summer overheating of well-insulated, air-tight dwellings with significant solar and internal heat gains. This presents a design challenge: to design dwellings in which acceptable internal temperatures can be maintained without resorting to air conditioning (which uses electricity and therefore generates more carbon dioxide emissions).

Non-Domestic Buildings

The number of non-domestic buildings in the UK is difficult to estimate[7]. However, best estimates suggest that in 1994 there were approximately two million non-domestic premises in the UK. Some premises embraced several buildings (e.g. college campuses), some formed only part of a building (e.g. office suites in a multi-tenanted office block), so the total number of buildings was probably also of the order of two million[8].

Figure 8 illustrates the approximate breakdown of the floor area of the non-domestic building stock by activity type. The small square at the top right–hand corner of the diagram represents one square kilometre of floorspace. Note that offices, retail buildings and industrial buildings make up approximately half of the floorspace.

Rates of growth and replacement vary from sector to sector, but the replacement rate is thought to average 1% per year and to be fastest in the retail and offices sectors. There is also some movement between sectors (e.g. conversion of dockside warehouses into dwellings).

Energy use and carbon dioxide emissions in the non-domestic building stock are less well understood than in dwellings, but similar considerations apply:

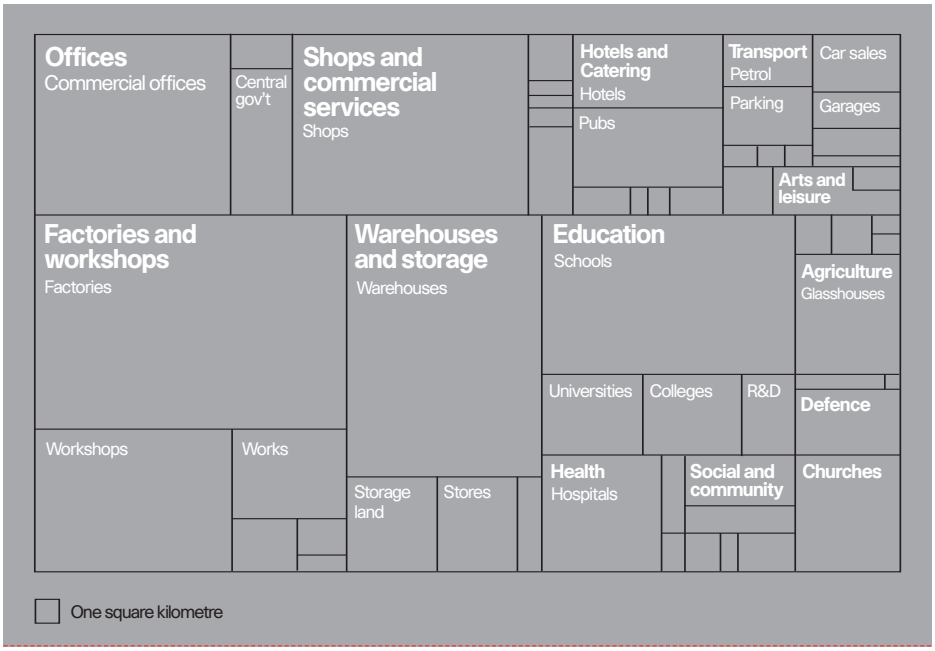

Figure 8 Diagrammatic representation of the breakdown of floorspace in the non-domestic building stock of England and Wales, 1994 (source: University College London)

6 *The 40% House*, Environmental Change Institute, University of Oxford, 2005

7 'An introduction to the national non-domestic building stock database', *Environment and Planning B: Planning and Design*, Steadman, JP et al, 2000

- New buildings contribute a small proportion of the total emissions
- Most existing buildings will still be in use in 2050
- Emissions reductions targets are unattainable without significant improvement of existing buildings and/or an increase in the replacement rate.

The 'energy intensity' (i.e. energy use per unit of floorspace) of non-domestic buildings, and the intensity of emissions, vary significantly with activity, built form and servicing type. Naturally ventilated buildings with good day-lighting use much less energy per square metre than 'deep-plan' buildings that rely on artificial lighting and mechanical ventilation or air conditioning. Air-conditioned open-plan offices use approximately twice as much energy as the same area of naturally ventilated, day-lit open-plan offices.

Energy use also depends almost as much on building occupancy patterns and management regimes as on design and specification.

More information about the energy performance of buildings appears in the RIBA *Carbon Literacy Briefing*.

RIBA Climate Change Policy

The Royal Institute of British Architects has adopted a robust Climate Change Policy, which has been developed over two years by the Policy & Strategy Group and the Sustainability Futures Group.

It acknowledges that individual architects and professional institutions such as the RIBA have limited opportunity to make a significant difference by themselves.

Architects are centrally involved in a sector of the national economy that is responsible for between 40% and 50% of UK national emissions. Therefore the RIBA and its members have a part to play and an opportunity to work with others to influence the future.

Tackling climate change requires concerted and focused action. This will include reducing carbon dioxide emissions by changing the ways in which buildings are designed, constructed, managed and used. The broad principles of sustainability or sustainable development are complementary to the measures needed to mitigate climate change, but addressing climate change has emerged as a matter that must be tackled in its own right.

Action to help mitigate and adapt to climate change is now starting to be undertaken by the built environment professions. The first step has to be towards raising awareness: not so much of the issue of climate change, but of the developing language and figures as they relate in particular to the built environment. Then it will be necessary to establish the scope of action accessible to architects and their clients, and the associated cost. From there, programmes of action, standards and skills for addressing key tasks (e.g. improving the existing building stock) can be developed. Other components of this Climate Change Tools package are designed to support this activity.

8 'Types, numbers and floor areas of non-domestic premises in England and Wales, classified by activity', *Environment and Planning B: Planning and Design*, Bruhns, HR et al, 2000

The RIBA's Climate Change Policy is set within the over-arching framework of contraction and convergence, and includes a plan of action with four key components:

Targets – the RIBA has adopted the policy of Contraction and Convergence as the overarching policy to guide targets for the reduction of GHG emissions associated with the use of energy in buildings. Contraction and Convergence involves a globally balanced approach to the reduction of greenhouse gas emissions to safe levels, consistent with the aspirations of different communities to development and quality of life.

Tools – the web-based package of Climate Change Tools is intended to provide critical, authoritative guidance for architects, their clients and their partner consultants about the standards and targets, measurement and assessment techniques, design principles, technical tools and skills that are necessary to the delivery of low-carbon buildings.

Corporate Behaviour – the RIBA is developing policies to guide reductions in its own impact, and that of its members, on greenhouse gas emissions, and to help them to take action.

Campaign – The RIBA will continue to organise lectures and events to promote greater public awareness of the climate change threat, and will join with other institutions to lobby Government and to influence other public and private organisations.

Other professional institutions (notably CIBSE) and organisations and agencies within the building industry are adopting parallel, complementary initiatives that have the collective potential to form the basis of a comprehensive industry-wide response to the challenge of climate change.

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