BUILDING CONTROL GUIDE TO SUSTAINABILITY

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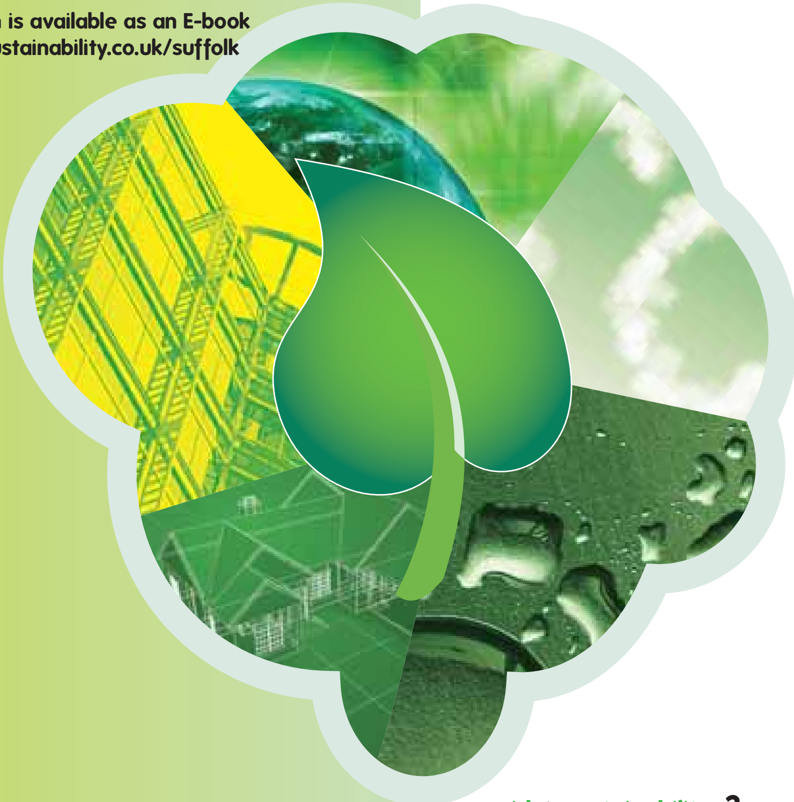


Why is Sustainability Important?

Sustainability is a very current topic, it is frequently in the news and we are constantly supplied with information about the state of the climate and the green credentials of various products and initiatives.

This guide will focus on what sustainability means from a Planning and Building Control point of view. Through a series of chapters it will look at some of the key issues and try to explore some of the options that we have available to us to reduce the impact that our buildings have on the environment around us.

This first chapter will look at some of the arguments as to why sustainability is important. There are a number of reasons why we should build in a sustainable way, some are altruistic, some economic and some simply practical.

Most scientists agree that our climate is changing due to the effects of global warming. It is thought that the CO_2 released into the atmosphere by the burning of fossil fuels by the industrialised world becomes trapped in the upper atmosphere and forms a layer that acts like a greenhouse, warming the earth below. The resulting temperature rises have the potential to upset the balance of the earth's climate causing polar ice caps to melt, sea levels to rise and established weather patterns to be disturbed. It is thought that if temperatures are allowed to rise beyond certain levels that the effects of climate

change will be irreversible and this could have catastrophic effects on the earth's eco systems.

The earth contains a finite amount of oil, coal and gas and this has been formed over millions of years. As we extract fossil fuels from the earth the reserves reduce and there will come a time when the reserves are exhausted. The UK's North Sea gas stocks have declined to the extent that we are now a net importer of energy. No one is sure how much oil remains in the earth for extraction and exploration continues to discover new oil fields. What is clear is that the oil that is being discovered is increasingly difficult to extract and much of it is located in far off areas of the world. As reserves become more difficult to exploit, the price of oil will need to rise to make extraction economically viable and if supplies become short, oil rich countries may be less willing to export their reserves. This will inevitably lead to rising energy prices and subsequent rises in our cost of living both directly in terms of heating and transport fuels and indirectly through the increased cost of manufactured and transported goods.

Since the industrial revolution the majority of the world's fossil fuel consumption has occurred in the Western world. In more recent times the developing economies notably in China and India have added significantly to the demand for oil and this pattern is likely to be repeated as other parts of the world develop.

The world's population is still expanding and as it increases demands on the environment grow. The World Wildlife Fund Living Planet Report 2008 calculated that currently global resource use exceeds earth's capacity to regenerate by approximately 30% and at current growth rates we would need two planets to support our demands by 2030. To use a financial analogy we are drawing down on earth's capital rather than living on the interest.

CO_2 production is a concern to governments across the globe. In the UK the government has made commitments to make significant reductions in UK CO_2 outputs. Within the UK 45% of CO_2 production is attributed to buildings, 27% of CO_2 production comes from dwellings and 73% of the CO_2 produced in dwellings is from space and water heating so this is a key area where the government feel that CO_2 emissions can be reduced. Since the 1980s, efforts have been made to improve the thermal performance of buildings, and houses in particular, and whilst improvements in performance have been made, there is concern that many of these CO_2 savings have been cancelled out by increased consumption from lighting and electronic gadgets. The Department for Communities and Local Government are suggesting a four step approach to reducing CO_2 emissions from the UK.

These are:-

1. Reducing Heatloss Through the Fabric of Buildings: the Building Regulations will be used to ensure that our homes are as energy efficient as possible.

2. Decarbonising the Grid: CO_2 emissions can be reduced if energy is produced in 'cleaner' ways. Most electricity is currently generated using coal or gas which produces CO_2. Increased use of renewables through wind, wave and hydro electric power and nuclear energy will be needed to make our energy supplies less CO_2 intensive.

3. Requiring Electronic Devices to be More Energy Efficient.

4. Changing People's Attitude Towards Energy Use.

Sustainability is, however, about more than energy supplies. A widely accepted definition of sustainable development suggests that

...'sustainable development meets the needs of the present without compromising the ability of future generations to meet their own need'... and this seems a quite reasonable aspiration.

Sustainable development encompasses much wider issues. It should respect our heritage and be accessible and suitable for the population that need to use it. Sustainable development must also consider the effects it has on its surroundings in areas such as flooding. This guide will focus on sustainability in terms of energy and water use but it is important to remember that true sustainability will only be achieved if the many other issues are addressed.

Planning Permission and Building Regulations consent affect buildings when they are newly constructed or altered. Improving the sustainability of buildings generally requires investment and disturbance to the occupants so there needs to be a catalyst to make these improvements happen. It is logical to try and make improvements when buildings are being constructed or other building work is being carried out and for this reason Planning Permission and Building Regulations are appropriate pieces of legislation to drive practical improvements in the environmental performance of the building stock.

There are clearly a number of reasons why it would be prudent to minimise our energy use and CO_2 production and to reduce our reliance on fossil fuels. Planning Permission and Building Regulations consent will not be able to solve all of the problems highlighted above but they will have a significant part to play in terms of reducing energy use, CO_2 production and fossil fuel demand from our buildings.

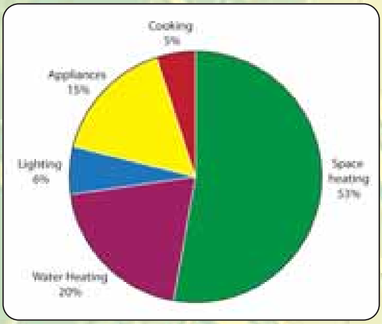
Within the UK, buildings are one of the largest users of energy and accordingly the largest generators of CO_2. Government figures suggest that 45% of CO_2 production in the UK is attributable to buildings and 27% of CO_2 is produced in our homes.

Buildings use energy for a number of processes and the graph below gives an indication of how energy use is broken down in a typical house.

Heating

It can be seen from the graph that, in a typical household, space and water heating accounts for around 73% of the energy used and that currently 80% of domestic heating is gas fired. Heat can escape through all building elements and to preserve energy it is important that the whole building is insulated to reduce heat loss. The figure below shows a representation of how heat is lost from a typical house.

Energy Consumption in Buildings



The Stern review suggests that our warming climate should reduce the demand for space heating and this, combined with improving insulation standards, should reduce our need for energy to heat our buildings.

Appliance Use

After heating, the next largest user of energy is domestic appliances. Recent data suggests that energy consumption by domestic appliances is increasing. Whilst many appliances are not fixed parts of the building and are not considered by building standards guidance as such, the Code for Sustainable Homes has started to include recommendations for fixed appliances and white goods.

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“Space and water heating accounts for around 73% of the energy used and that currently 80% of domestic heatinng is gas fired”

Lighting

Lighting is another main user of energy in housing and even more so in commercial buildings. Careful selection of lighting units, including external lighting, controls and switches can reduce energy use in this area.

Cooling

Generally speaking, cooling requires more energy than heating and in commercial buildings, especially those with large numbers of computers, cooling is often the largest energy user. With the anticipated warmer summers, increasing cooling requirements and the development of the domestic cooling market are concerns when trying to reduce energy use.

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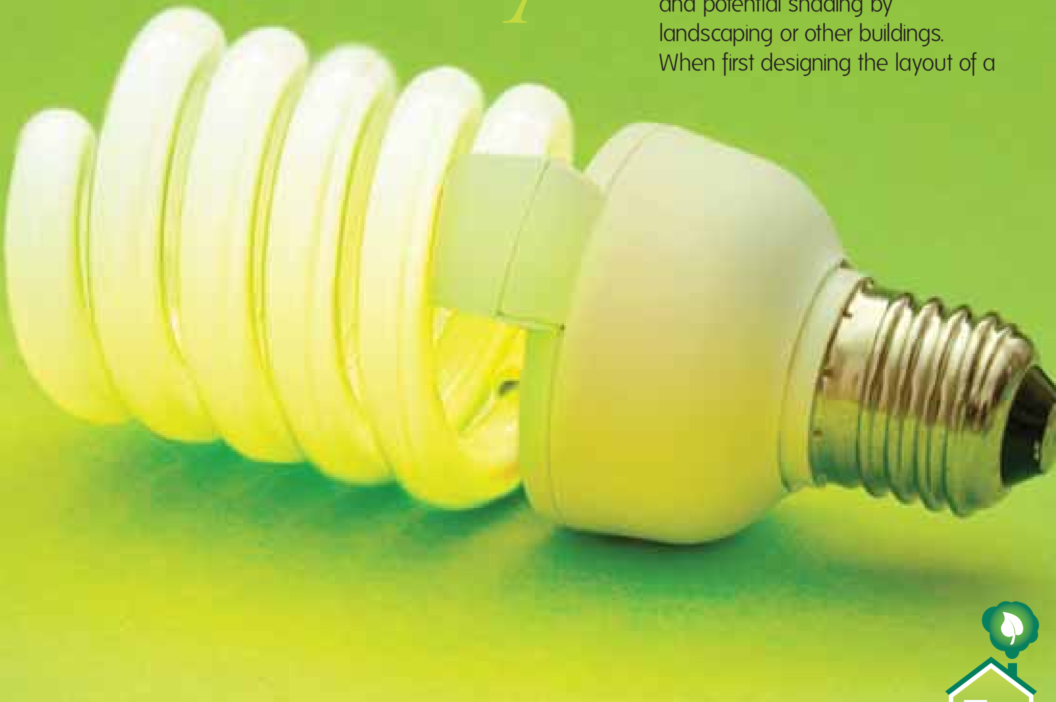
If we are to build sustainable buildings it is important that preserving energy is considered as part of the design process. When designing a building, careful consideration of the layout can make the most of sunlight, shelter and natural ventilation to create buildings that are naturally comfortable for their occupants, reducing the need for artificial heating, lighting and cooling.

Using Energy Efficiently

Passive solar design exploits the free heat and light energy provided by sunlight entering buildings through windows, and uses air movement for ventilation. This can be extremely effective when combined with heavy construction materials which heat up and cool down slowly, good insulation, and shading to prevent excessive solar gain in summer.

To take full advantage of these opportunities, designs must consider factors like sun orientation and potential shading by landscaping or other buildings. When first designing the layout of a



site and the design and layout of buildings we need to make sure the possibilities are thought about at the earliest stages of planning the development.

The extent to which the benefits of passive solar design can be used will be influenced by the constraints of the site on which the project must be constructed; the orientation of a rear extension will inevitably be fixed by the existing building, but application of the principles of passive solar design can still result in significant energy savings and comfortable living spaces.

Benefits of passive solar design include:

- Simple layout and building design principles can achieve savings of up to 10% of fuel costs for heating and cooling.
- Passive solar developments need cost no more than 'conventional' developments.
- Good layout and design results in natural comfortable spaces that are attractive to users.
- Passive solar design is not dependent on technology and has no ongoing cost implications.

Careful orientation is vital for passive solar energy gains. The elevation with the largest proportion of glazing of each building, or extension should be orientated within 30° of south (solar orientation) with a smaller proportion of glazing on the north elevation. Over shading by other buildings should be minimised.

Deep-plan buildings, e.g. offices, tend to be highly energy dependent, with the middle of the building needing electric lighting and mechanical ventilation throughout the day. Large buildings should be designed to give all occupants access to natural light and ventilation, either by a more complex form, or with courtyards, light-wells or atria which introduce light and air deep into the building.

Trees that will grow to overshadow buildings should be deciduous so that they allow sunlight to pass through the bare branches in winter yet provide shading in summer. Shelterbelts, made up of mixed species, can be located to the north of development, or where they will give shelter from the prevailing wind. They should be distanced 3-4 times their mature height from south-facing elevations. Green space can also reduce storm water run-off and helps lower the risk of urban flooding.

With predicted increases in summer temperatures, building design will need to ensure there is adequate cooling to prevent uncomfortable internal temperatures. The most sustainable way of achieving this is through natural ventilation. At its simplest this takes the form of windows which can be opened by adjustable amounts. Positioning opening windows or air vents on opposite walls draws fresh air through the building.

Night cooling provides ventilation that is secure enough to be left open at night. It is a very effective way to bring down the temperature of a building and takes the form of windows with a secure open position, or air vents in the wall. It works best if the building has a high thermal mass which can absorb heat throughout the day and then disperse heat as it cools overnight.

External shading from adjustable awnings and shutters, or permanent sun louvres, can block out sun when it is high in the sky in summer, but still allow sun in when it is lower in the sky in winter or early and late in the day. South facing windows actually make this form of shading more effective. Internal shading, e.g. blinds, is less effective for reducing excessive heat gains.

In urban areas, green spaces provide some respite in extreme heat. Planting can provide shade for amenity areas and car parking in summer.

Passive solar energy construction does not need to be significantly different in appearance to conventional buildings. If it is possible to achieve good solar orientation (see layout guidance above), the following measures should be included:

Glazing: a rule of thumb is to have a conventional amount of glazing but to locate 70% of the glazing on the south elevation. If windows are too large, heat loss may outweigh solar gain, and occupants' desire for privacy is likely to lead to installation of net curtains or blinds which block out the solar gains. There should be less glazing on the northern elevation, although windows that provide sufficient daylight and ventilation to the room are recommended.

Internal Layout: locate well-used rooms requiring warmth and light on the southern side. In a house this will probably be the main living rooms and largest bedrooms. Locate less well-used rooms, those requiring heat generating appliances, and rooms that should be cool, on the north side of the building. In a dwelling this could be the kitchen, bathroom, utility room and garage. In a commercial development this could be storage areas, or the location of working machinery which will generate heat as a by-product.

Thermal Mass: solid heavy walls and floors absorb heat slowly in warm conditions, and give it out slowly again when it is cooler.

Insulation: well-insulated walls and roofs make the most of the heat gained through passive solar design and these will be discussed in more detail later in the chapter.

Once the orientation and form of the building have been designed, careful consideration should be given to the technical aspects of energy design. Chapter 2 explores how energy is used in buildings. A well-designed building will minimise the energy input required to create comfortable internal conditions and will ensure that the energy that is required is generated and used in an efficient way.

Heat Loss and Insulation

Much of the energy consumed by buildings is used for heating. Buildings tend to be maintained at temperatures that are above the external air temperature and the heat within our buildings is constantly trying to escape. One way that it does this is through the materials that make up our buildings, the fabric. Heat is lost through the walls, roofs, floors and all other exposed surfaces of our buildings. Where buildings are cooled, the same principle applies but in reverse, as the hot air from outside comes into the building and raises the internal temperature.

Heat loss can be reduced by adding thermal insulation to the walls, roofs and floors that enclose our buildings. Building materials allow heat to pass through them at different rates. Some materials such as steel are good conductors of heat and they allow heat to pass through them very easily, whereas other materials such as fibreglass offer much more resistance to the passage of heat and these are known as insulants. A well-insulated building will reduce the amount of heat that escapes, this will reduce the demands on the heating system and it will therefore be more energy efficient than a poorly insulated building.

To help us compare how effective various types of construction are at reducing heat loss we use a measure called U Value. This is a measure of how much heat is lost for every m^2 of an element based on a one degree temperature difference. It is expressed in W/m^2K, so if a house wall had a U Value of 0.25 W/m^2K, each square metre of the wall would lose 0.25 watts for every degree of temperature difference there was between the inside of the house and the outside.

It can be seen from this that lower U values are an indication of better thermal performance.

U values can be used to measure the performance of any external part of the building and the following paragraphs explore some of the options available to improve the thermal performance of the building elements.

Walls: most new walls constructed in the UK are cavity walls. These walls are formed from two skins of masonry tied together with a gap known as a cavity in between. This cavity can be filled with insulation to improve the thermal performance of the wall. This reduces the amount of heat lost and improves the thermal performance of the building. Where walls are made from timber frame units or cladding panels a similar principle applies. The U value of the wall is related to the thickness and quality of the insulation that is placed within the wall and thicker, better quality insulation materials give lower U values. When considering exposed sites, care must be taken to ensure that water and driving rain cannot enter the building.

Roofs: these can take a number of forms. In simple pitched roofs insulation can be placed in the loft above the ceiling to reduce heat loss. With sloping ceilings or with flat roofs the insulation layer can be placed above, between or below the roof timbers depending on the space available. Generally speaking with sloping ceilings and flat roofs higher quality insulation materials are needed to achieve suitable levels of insulation and thicker, better quality insulation will give lower U values. It is important to ensure the insulated roofs have adequate ventilation or vapour controls to prevent timber decay.

Ground Floors: although heat rises, significant amounts of heat can be lost through ground floors. To restrict heat loss, floors should include an insulation layer. This can be provided in a number of ways: with concrete floors, flooring grade insulation can be placed below the concrete or screed and with suspended timber floors, insulation can be placed between the floor joists. As with walls and roofs, thicker, better quality insulation will give lower U values.

Windows and Doors: well-fitted high performance windows and doors can make a significant difference to the performance of a building as a large proportion of a building's heat is lost in this area. Double or triple glazed windows with low emissivity coatings can reduce heat losses and should be specified wherever possible.

Cold Bridging and Junctions: as insulation levels of the various building elements improve the heat loss, the junctions between them becomes more significant. To reduce this issue, care should be taken to ensure that the insulation layers all link together so that the building is enclosed in an insulated envelope.

Good insulation can make a huge difference to the amount of energy required to heat or cool a building. It is permanent and does not require energy to run it, cannot be switched off and is key to energy efficient design.

Air Tightness

If the fabric of a building is well insulated and the junctions are carefully detailed, another large area of heat loss could be through air leakage. If a building is not airtight, warm or cooled air will escape and energy will be required to heat or cool the replacement air to ensure that comfortable conditions are maintained inside the building.

Some air movement and ventilation are essential to ensure comfortable living conditions for the building users, but excessive ventilation is not energy efficient.

Careful sealing of the building and controlled ventilation are a key part of energy efficient design. When designing and constructing a building care should be taken to ensure

that all junctions are designed to limit air leakage and all service entries should be carefully sealed. Airtight membranes can be included within the building to reduce leaking air and buildings can be air tested on completion to ensure that they are reasonably airtight.

Heating and Ventilation

Even with the highest standards of energy efficient design most buildings will still require heating or cooling input. By maximising the benefits of passive solar design, building insulation and air tightness, the energy input required by the building should be minimised and to build sustainably we must ensure that this energy is created and controlled in the most efficient manner possible.

Once demand has been minimised, the most sustainable way of heating and cooling a building is by using renewable energy. A number of on site renewable energy options are explored in some detail in Chapter 6 of this guide and the choice of how the building demands are met will be largely site dependent. If renewable technologies are not appropriate or feasible it is still important to ensure that the building's requirements are met in the most efficient way possible. Condensing gas or oil boilers are very effective and can often be combined with renewable technologies to create highly efficient buildings.

As buildings become more airtight, ventilation design becomes more important as we can no longer rely on draughts and air leakage to provide the air that we need. For energy efficient design, controlled ventilation is required to ensure that adequate air is delivered where it is needed and this will ensure comfortable environmental conditions but avoid wasting energy heating or cooling unwanted air. Proprietary whole house ventilation systems are now available, some of which include heat recovery units to ensure optimum internal conditions with minimum energy input.

Building Controls

To ensure that energy is used efficiently, building controls have a vital part to play if we are to build sustainably. Without adequate controls, energy can be wasted heating and lighting spaces that are not occupied, or worse still, cooling buildings which are overheated because occupants cannot turn the heating down.

The level of controls that are needed will be determined largely by the size and use of the building. The simplest controls are time switches that allow users to program heating systems to turn on and off to suit their lifestyles. Thermostats, room stats and radiator valves improve control of heating systems as they will shut down the boiler to stop heat being wasted once a set temperature has been reached. Where multiple thermostats or radiator valves are installed they allow different parts of a building to be kept at different temperatures and allow some parts of the building to be unheated if, for example, they are not in use.

More complex buildings can be fitted with complete building management systems. These monitor internal and external temperature and, using computer software, ensure that the building services are used to their optimum efficiency.

Lighting can also be controlled through a variety of systems: Passive InfraRed (PIR) sensors can be used in toilets and rooms that are not always used and the simplest controls can be provided by local switches that allow users to switch off lights that are not required.

The best sustainable buildings will combine all of the factors mentioned above; their designs will minimise energy use, optimise renewables and will generate and use energy efficiently to create sustainable comfortable spaces.

Sustainability, Planning and Building Regulation Requirements

Planning Permission and Building Regulation consent are required for all significant developments and sustainability is a key theme that runs throughout these pieces of legislation. This chapter will summarise some of the key areas that should be taken into account when considering a development.

National Planning Policy

The overarching principles in respect of delivering sustainable development through the Planning system are contained in:

PPS1 – Delivering Sustainable Developments (2005): the PPS suggests that 'Sustainable development is the core principle underpinning Planning' and provides a series of principles that should be considered for achieving sustainable development, these are:

- Social cohesion and inclusion
- Protection and enhancement of the environment
- Prudent use of natural resources
- Sustainable economic development.

Below PPS1 are a number of supplementary guidance documents that provide more detail about how the aspirations of PPS1 should be delivered. Key guidance includes:

Supplement to PPS1 – Planning and Climate Change (2007): this sets out how Planning should contribute to stabilising the climate by reducing greenhouse gas emissions and ensuring that development is adapted to the possible effects climate change may bring about. It suggests that sustainable development should 'Provide new homes, jobs, services and infrastructure needed by communities, and renew and shape the places where they live and work, secure the highest viable resource and energy efficiency and reduction in emissions.'

PPS22 – Renewable Energy and Companion Guide (2004): advises Local Planning Authorities to encourage development of renewable energy infrastructure that can reduce overall CO_2 emissions from the UK.
It recognises the value that small scale renewable energy systems can have when looking to reduce overall CO_2 emissions.

PPS25 – Development and Flood Risk (2010): ensures that flood risk is considered at all stages of development. It seeks to keep development away from the highest areas of flood risk and ensure that development does not unduly increase flood risk elsewhere.

Supplement to PPS25 – Practical Guidance to Flood Risk (2009) ensures that flood risk is considered at all stages of development. It seeks to keep development away from the highest areas of flood risk and ensure that development does not unduly increase flood risk elsewhere.

> "Sustainable development should provide new homes, jobs, services and infrastructure needed by communities, and renew and shape the places where they live and work, secure the highest viable resource and energy efficiency and reduction in emissions"

Regional and Local Planning Policy

Please refer to individual authorities local policies for further guidance.

Building Regulations

As well as meeting Planning Permission requirements developments will also have to comply with the Building Regulations and sustainability requirements appear in several areas.

Part L of the Building Regulations covers energy use. The energy use of new buildings is assessed using a Standard Assessment Procedure (SAP) for housing and Simplified Building Energy Model (SBEM) for non-domestic buildings. These are standard methods of calculating the design energy use of a building approved by the government.

“The government are committed to tightening the energy standards within the Building Regulations and this will be achieved by progressively lowering TER values until Zero Carbon status is achieved”

SAP and SBEM assess a building’s performance in terms of thermal insulation, air tightness, heating and ventilation efficiency, fixed electrical consumption and overheating potential. They take account of any energy provided from renewable sources and produce two figures:

TER – the carbon emission rating required by the Building Regulations.

DER (Domestic) or BER (Non-Domestic) – the anticipated carbon emission rate for the building as designed.

To show compliance with the Building Regulations the DER or BER must be lower than the TER.

The government are committed to tightening the energy standards within the Building Regulations and this will be achieved by progressively lowering TER values until Zero Carbon status is achieved (see Chapter 5), the current programme proposes that this level is achieved by dwellings in 2016.

Part G of the Building Regulations includes guidance on water use in dwellings and, using a standard calculation method, it has to be demonstrated that the design water consumption of each house or flat does not exceed 125 litres per person per day.

Part H requires soakaways and infiltration drainage to be used for rainwater disposal wherever possible to reduce the storm loading on the sewer system and the subsequent flooding risk.

As well as Planning and Building Regulation requirements there are other areas that need to be considered. The more common assessment tools include:

The Code for Sustainable Homes: this takes a holistic look at the sustainable credentials of new houses. Assessments are made against nine separate categories ranging from energy and water use through to ecological impact.
A scoring system is used to combine the results into a Code Rating between 1, the entry level, and 6, the highest level, which is a zero carbon home. All new houses should receive a rating against the Code for Sustainable Homes and this should allow purchasers to make more informed choices.

BREEAM: this is a system broadly similar to the Code for Sustainable Homes that is applied to non-domestic buildings. It produces a rating that allows the relative sustainability of non-domestic buildings to be compared.

"The Local Planning Authority relevant to the development site will have a Local Plan or Local Development Framework which will contain requirements and advice"

Energy Performance Certificates: all buildings must have energy performance certificates when they are built or sold. The certificates give an indication of the likely energy use of a building and have a rating system similar to the one used on domestic appliances, an A rated building being more efficient than an E rated building. The certificates also contain information about a building's potential energy rating if basic improvements were carried out. Energy Performance Certificates are intended to provide purchasers with energy information about the building they are purchasing and to highlight the benefits that could be achieved if they invested in building improvements.

In summary, there is a wide range of legislation that affects new development, much of it is interrelated and it all seeks to improve the environmental performance of the buildings that we construct and use.

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What is ZERO Carbon Dioxide?

The government has made a commitment that all new homes constructed after 2016 will be zero carbon. The Code for Sustainable Homes offers two definitions of zero carbon.

At code level 5 homes should, over a year, have zero net emissions of carbon dioxide in respect of the energy used for heating, lighting and ventilation.

At code level 6, the highest level achievable under the Code for Sustainable Homes, homes should have zero net emissions of carbon dioxide in respect of heating, lighting, ventilation and all other energy used in the house including appliances.

At the current time it is not clear which definition the government will use but it is clear that meeting either definition will present everyone with a significant challenge.

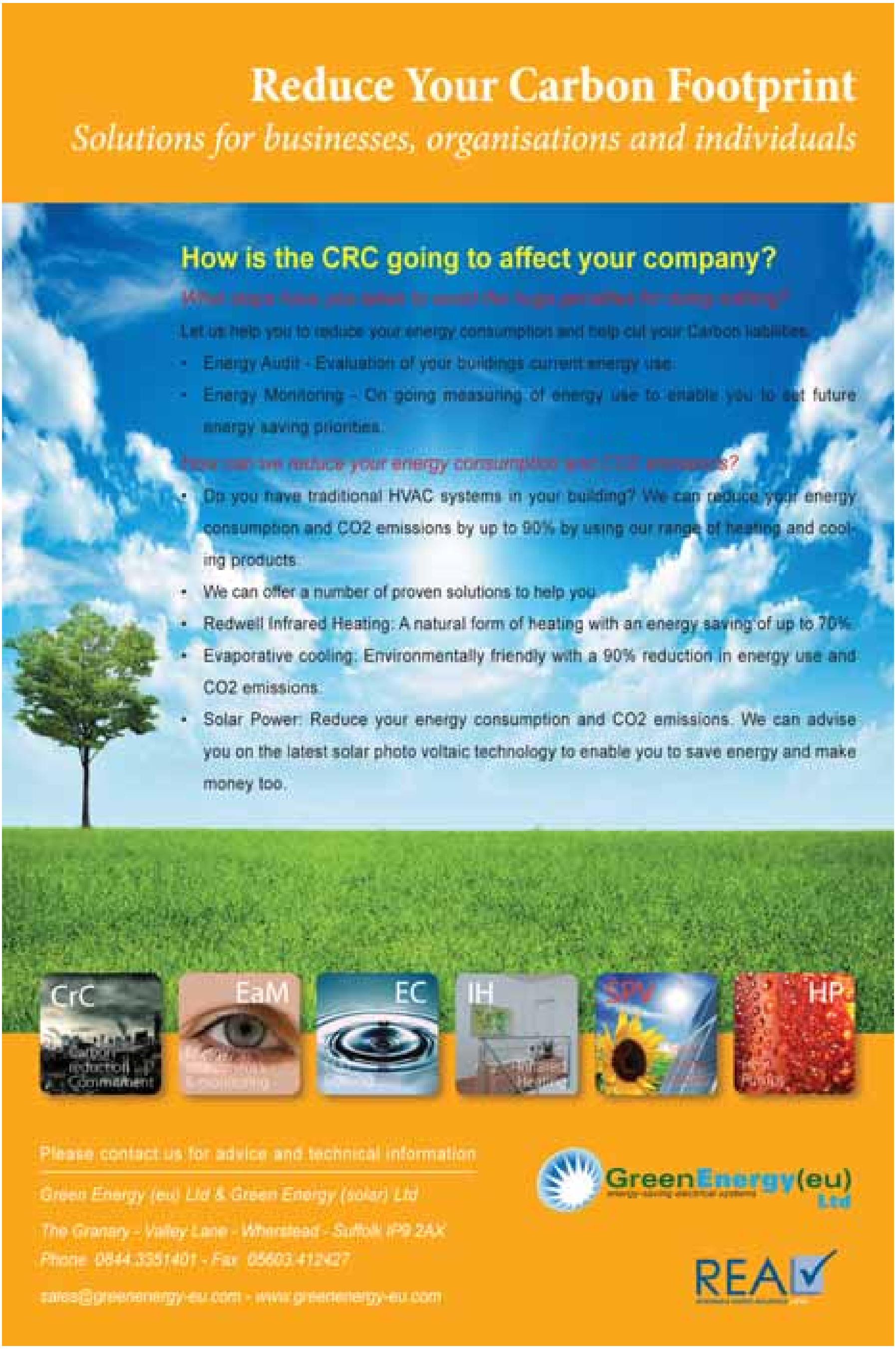
In 2008 the government commissioned a study from The Green Building Council which concluded that 'requiring all CO_2 emissions to be mitigated on-site would be physically impossible on the vast majority of new dwellings'. In response to this a new approach to zero carbon where energy efficiency, on-site renewables and a new concept of 'Allowable Solutions', made up of low and zero carbon energy generated was devised.

This new method acknowledges that we will only be able to move to zero carbon housing through a properly coordinated programme of improvements.

The first step is to build homes to the highest practicable standards of energy efficiency and research is currently being undertaken to see how far we can realistically push up air tightness and thermal insulation standards. It is important to maximise the benefits in this area as good energy efficiency can significantly reduce the amount of energy that we will need to generate to power our homes.

When energy efficiency has minimised the energy requirements for new homes it is proposed that as much as possible of the homes' remaining energy needs are met by renewable energy sources installed on site. Chapter 6 provides more details of the small scale renewable technologies that can be used to generate both heat and electricity for homes and these should meet a significant portion of the energy requirements of an efficient home.

It is acknowledged that having maximised the benefits of energy efficiency and on site renewables, energy will still need to be imported to the site. If we are to move to zero carbon housing we will need low carbon energy to be produced through projects such as wind farms and tidal schemes so that this can be imported to the site, and the government's ambition of building zero carbon housing can be achieved.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REAL

renewable ENERGY

One way of reducing the CO_2 impact of a development is to look to maximise the use of renewable energy. This is energy that does not rely on diminishing fossil fuels but uses the natural resources around us to create useful energy with low environmental impact.

Large scale renewable energy installations such as wind farms and tidal barrages can feed significant amounts of renewable electricity into the National Grid and going forward these are likely to make a significant contribution to our moving to a low carbon economy. At a more local level, nearly all sites have some potential to create energy through the use of micro renewables and this should not be ignored. The selection of the most appropriate technology is the key to the successful implementation of a micro renewable installation and in this chapter we will explore some of the more common solutions that are available.

Solar Thermal (Water Heating): with this technology, heat from the sun is used to heat domestic water. Generally, solar panels are mounted on the roofs of buildings and these capture heat from the sun and transfer it to a liquid (a mixture of water and antifreeze) which is then circulated through a coil in the hot water cylinder to heat the domestic hot water.

A wide range of panels are now available and they generally fall into two categories:

1. Flat Plate Collectors: these tend to be the least expensive and lowest profile systems; they can also be the least visually intrusive.
2. Evacuated Tube Systems: these tend to be more expensive, but as they are generally more efficient, smaller arrays can be installed to meet the building's energy requirements.

In new build developments, panels can be recessed or designed into roofs to minimise visual impact.

The effectiveness of Solar Water Heating depends largely on the amount of sun that is available. Panels should ideally be installed on unobstructed roof slopes that face south, southeast or southwest. In the UK, climate back up systems are required, usually from the central heating boiler, to cope with dull days or times of high hot water demand. Solar water heating systems in the UK can typically provide between 55% and 70% of the hot water requirement and for a 3 bedroom house 3-4m[1] of panels are normally required.

With the panels installed, there are a number of ways of connecting the panels to the domestic hot water system. The system designer must ensure that suitable controls and safety devices are in place and the most common systems use a dual coil hot water cylinder. The solar panels are connected to a coil in the bottom of the hot water cylinder and the back up system connects to a coil in the upper part of the cylinder.

Solar Electric (Photo Voltaic): this technology captures energy from the sun and using semiconductor material, converts it to electricity. This can then be fed through an inverter into the buildings' electricity system or, subject to suitable connections and licences, fed into the National Grid.

Most systems use roof mounted panels which are ideally sited on an unobstructed south, southeast or southwest facing roof. For new build or re-roofing projects, photovoltaic slates or tiles could be considered as these integrate into the roof of the building and are less visually intrusive.

The amount of electricity generated by the panels is dependent on the sunlight available and the area of panels installed.

Heat Pumps (ground source and air source): heat pumps extract heat from their surroundings and using a compressor upgrade it to a higher temperature. They are generally driven by electricity and work on the same principle as a domestic fridge. The efficiency of a heat pump is measured by its coefficient of performance (COP) and generally, for every unit of energy fed into a heat pump, 3-4 units of heat are produced, depending on the COP of the heat pump chosen.

All heat pumps require a source of heat and the most common heat pumps use either ground or air as their heat source.

Ground source heat pumps extract heat from the ground around the building. An underground network of pipes are installed either in vertical or horizontal loops depending on the nature of the site. A mixture of water and antifreeze is then circulated through the pipes; the heat is extracted from the liquid and compressed by the heat pump to produce useful heat that can be fed into heating and hot water systems.

Air source heating systems work on a similar principle, but instead of using an underground network of pipes, they take their heat directly from the surrounding air. This can significantly reduce installation costs, but the resulting systems tend to have a lower COP and are therefore less efficient.

It is generally thought heat pumps work best when they are operating at relatively low temperatures. This makes them especially compatible with low temperature heating systems such as under floor heating and with well insulated buildings that have a high thermal mass.

Because they require electricity to run them, heat pumps are not strictly speaking a renewable energy source, so to gain environmental benefits it is important that

an efficient heat pump is selected and that the building is designed to maximise the benefits that the heat pump offers. Another advantage of heat pumps is that they can often be reversed to provide summer cooling if required.

Biomass: this system uses plants, generally trees, as a fuel source. Timber is burnt to produce heat which is then used to heat buildings, either directly through a central heating system or to heat water. Plants respire using a process known as photosynthesis. As plants grow they take in carbon dioxide and emit oxygen, the carbon dioxide is held within the plant until, when used in a biomass heating system, it is burnt. Providing that another tree is planted to absorb the carbon dioxide emitted by the tree being burnt, a sealed carbon cycle is created and the energy can be considered renewable.

Biomass can be used in buildings in a number of ways. At its simplest, a log burning stove uses biomass to produce direct heat. At the more complex end, biomass boilers using wood pellets can provide effective heating for very large buildings. Issues to be borne in mind when considering biomass include the availability of the fuel and the storage of the fuel, which is bulky. Also, biomass is not the most controllable of fuels, as some biomass devices cannot automatically shut down and restart.

Wind Turbines (small scale): wind turbines use the power in the wind to rotate blades which turn an electricity generator. The electricity generated is then passed through an inverter into the building's electricity system or, subject to suitable connections and licences, fed into the National Grid.

The amount of electricity generated depends on the wind available and generally the higher that the turbine is located the more reliable the wind source will be. Large scale, well located wind turbines have proved to be a very effective way of generating electricity. In domestic situations, building mounted turbines have suffered with the effects of turbulence caused by adjoining trees, buildings and structures. When considering small scale wind power it is important to get an accurate local appraisal carried out to establish how much electricity the turbine will realistically generate in the proposed location.

When considering any renewable installation it is important to think about the effects it will have on the supporting building, such as the additional loading panels will place on roofs etc, along with any ongoing maintenance requirements for cleaning etc. When choosing a technology it is also important to think about potential future developments and to try and avoid things like placing panels where the sun could be blocked out by growing trees or future extensions, as far as possible.

In some circumstances it may be appropriate to use more than one type of renewable energy source and the technologies can often be used in combination to produce highly efficient buildings.

Water Management

Water is a key element for living and in terms of sustainability, water management can be considered in two main areas; clean water use and management of rainwater.

Clean Water Use: as the UK population grows and our standard of living improves the demands placed on our water systems increase. The problems this can cause are exaggerated when the large populations live in concentrated areas as happens in large towns and cities, especially when most of these are located in the South East of the UK as this area has the lowest levels of annual rainfall.

The UK does not currently have a national water grid so even with our temperate climate and relatively high annual rainfall careful water management will be required to meet our future water demands.

Treating water so that it is suitable for drinking also requires relatively high levels of energy input, and as much of this energy will produce CO_2, good water management makes sense if we are looking to reduce our CO_2 output.

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“Aerating taps work by mixing air into water as it comes out of the top. They have the effect of increasing the surface area of the water meaning that you need less for things like hand washing.”

When looking to manage water consumption a key factor is reducing use. A number of options are available to help achieve this and these include:

1. **Aerating Taps:** these work by mixing air into water as it comes out of the tap. They have the effect of increasing the surface area of the water meaning that you need less for things like hand washing. Aerated taps are best suited to wash hand basins and other areas where things are washed in the water stream. They are less well suited to sinks and baths as here a fixed quantity of water tends to be needed to fill the bath or bowl.

2. **Aerating Shower Heads:** these work on a similar principle to aerating taps. The design

of the shower head reduces the flow of water required to give a comfortable pressure for the user in the shower thereby reducing consumption.

3. **Small and Shaped Baths:** the amount of water used by a bath is largely determined by its volume. By fitting smaller or carefully shaped baths, water consumption can be reduced without significant effects on the user's comfort.
4. **Efficient White Goods:** a significant amount of water is used by appliances such as washing machines and dishwashers. A lot of modern appliances incorporate water saving technologies to reduce their water consumption.
5. **Dual Flush WCs:** these have two different flush volumes so that water is not wasted when only a small flush is required. Typical dual flush toilets have a 4 litre and 2 litre flush and this can add up to a significant water saving over the course of a day.
6. **Greywater:** greywater systems collect water that has been used for washing and, after filtering, reuse it for things such as toilet flushing where drinking water is not required. Greywater can significantly reduce the amount of water used but it is essential that greywater is not allowed to contaminate the drinking water supply.
7. **Rainwater Harvesting:** this involves collecting rainwater for things such as watering plants and garden. At its simplest, a water butt can be added to a rainwater down pipe or more complex tank and pump systems can be installed depending on the amount of water that is required.

From April 2010 the UK Building Regulations require that all new housing constructed has a design water use per person of not more than 125 litres per person per day. A standard calculation method will be used to work out how much water each house will consume when used in a typical way. The Code for Sustainable Homes takes this requirement further and points are awarded for reducing design water consumption down to as low as 80 litres per person per day. The allowance in the Building Regulations is likely to be reduced in the future as houses are expected to meet more demanding standards.

> "Treating water so that it is suitable for drinking also requires relatively high levels of energy input, and as much of this energy will produce CO_2"

Rainwater Management: current weather patterns mean that rainfall tends to fall in short sharp bursts, and as a result of this we get large volumes of water to deal with in relatively short spaces of time. As our country becomes more developed more areas are covered in hard surfaces such as roads and paving and the water from these surfaces has to be drained.

When the volume of water flowing exceeds the capacity of drainage systems flooding occurs and the risk of this needs to be minimised. There are several methods available to reduce the risk of flooding and some of the more common methods are explored below.

1. Infiltration Drainage: this relies on the ability of the ground to absorb water. Most subsoils will soak up some water, more porous soils such as sands and gravels can generally absorb larger amounts of water than less porous soils like clays. If water can be absorbed by the ground close to where it falls it does not need to be drained away and the risk of flooding is reduced. Porous paving and soakaway drains are common types of infiltration drainage that can be used to reduce the loading on our drainage systems.

2. Attenuation: a lot of our drainage infrastructure, sewers and culverts etc. is old and was not designed for the drainage loads that we now need it to carry. To reduce the risk of flooding we need to ensure that the amount of water that goes into our drains does not exceed their capacity. One way of achieving this is to use attenuation where a control pipe is used to limit the water flowing off a site to a level that can be coped with by the surrounding drainage system. The water that cannot escape is held on the site in a tank or pond until it can safely flow away after the storm has passed over. Balancing ponds and storm tanks are common types of attenuation drainage.

If we are to build in a sustainable way it is essential that clean water use and rainwater run off are properly managed.

The Existing Housing Stock

There are currently around 26 million dwellings in the United Kingdom. In an average year new house building accounts for less than 1% of total housing so it is clear that even if we are successful in reaching the demanding targets proposed for new housing over the next few years. it will have a relatively modest effect on our overall energy use unless we take steps to improve our existing housing stock. To put it another way 90% of our homes for 2020 have already been built.

Refurbishment of existing houses presents a wealth of challenges and opportunities and there are a number of areas where improvements can be made.

1. **Building Insulation:** the first area to consider is the insulation levels in our homes. Significant energy savings can be made by improving insulation to walls and lofts. Insulation materials are relatively inexpensive and government incentives are sometimes available to encourage home owners to carry out this type of work. Top up insulation can often be added to lofts and homes with cavity walls can have insulation injected.
   In the UK 43% of homes have solid walls and these are more difficult to insulate as the walls have to be lined with insulation.

This can significantly reduce room sizes if placed inside and can cause problems with roof overhangs and junctions if installed externally. The construction industry has been challenged to come up with new products to overcome these issues and research into products such as thin insulating gel materials which may overcome this problem is currently being carried out.

2. **Doors and Windows:** another area where houses lose a lot of heat is through the doors and windows. Heat is lost directly through the door and windows themselves and also through any gaps around them. Modern windows have to be draught proofed, double glazed and have a heat reflective coating on the glass. When all of these improvements are combined a well fitted modern window saves approximately 2/3rds of the heat that would be lost through an equivalent single glazed window. As heat loss through doors and windows account for a large part of the total heat loss from the house it is clear that replacement doors and windows can make significant improvements to the performance of existing buildings.

3. **Air Tightness:** As well as the heat that is lost though the fabric of the building a significant amount of heat is lost through draughts and other air leakage into houses, for example, around service entries and windows etc. Effective draught proofing work can make significant energy savings.

4. **Efficient Services:** As well as minimising the heat loss from our buildings if we are to improve the performance of existing houses we must also make sure that we generate the heat that we need as efficiently as possible. The most sustainable way to generate heat is arguably to use a renewable energy source (see below). Where this is not possible or where the renewable system needs a back up we should consider energy efficiency when replacing boilers and heating systems. In recent years heating systems have become much more efficient and modern condensing boilers can achieve efficiency ratings of well over 90%. Combination boilers can reduce losses from standing hot water cylinders and, where hot water cylinders are still required, the design of hot water cylinders has also improved significantly in recent years. Improved heating systems can help to reduce demand for fossil fuel.

5. **Renewable Energy Sources:** Chapter 6 provided details of some of the renewable energy sources that can be used in buildings. Many of these systems can be installed onto existing houses and whilst the systems can be expensive to install the energy savings

> "In the UK 43% of homes have solid walls and these are more difficult to insulate"

can also be significant. Renewable energy sources have the potential to significantly reduce CO_2 production from existing houses.

6. **Controls:** as energy becomes more scarce and expensive it is important that we use it carefully. Modern heating and ventilation controls allow houses to use energy more effectively. Zoning and thermostatic controls can ensure that we only use the energy that we need and this can reduce our overall energy demand.

When considering work on existing buildings a decision has to be made about when it is best to carry out improvement works. When it involves replacing things such as windows or boilers that have not necessarily reached the end of their useful life, a balance needs to be struck between the energy costs of the early replacement of an element and the energy savings that the new element could deliver. Other factors may also need to be considered if for example the building is Listed or in a Conservation Area and of course the budget that is available to carry out improvements.

"Zoning and thermostatic controls can ensure that we only use the energy that we need and this can reduce our overall energy demand"

All of these considerations will influence decisions about what work is carried out and when. However, it is clear that if we are to significantly change UK energy demands improvements will have to be made to our existing housing stock.

Conclusion

The introduction to this guide suggested that there were a number of reasons why sustainability is an important issue. The guide has looked at the specific issue of what sustainability means from a Planning and Building Control point of view and hopefully the information provided within it has been useful and informative.

In terms of sustainability, as well as preserving resources, the Planning process touches on a wide range of other sustainability related issues. Anyone proposing development should for example make themselves aware of their responsibilities in respect of issues such as archaeology, biodiversity and protected species as these will often affect development. It can easily be argued that one of the key aims of the whole Planning process is to ensure that development is sustainable.

On a global scale the scope of sustainability of course goes far beyond the influences of the Planning and Building Control systems into major geo-political issues such as allocation and use of natural resources and the desirability of economic growth and prosperity. Much has been written about this elsewhere and these issues will no doubt continue to be discussed.

Whilst acknowledging that the Planning and Building process is a small part in the larger sustainability jigsaw it is hoped that this guide has shown that our buildings make a significant contribution to our environmental footprint and that through careful design and construction we can minimise their environmental impact whilst still producing quality buildings.

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