Design Guide 12
Sustainable Building Design

12.1 SUSTAINABLE BUILDING DESIGN

Although the earth's climate is in a state of continuous natural change, most scientists agree that the speed and intensity of this change is largely due to human activity, and in particular the heavy reliance on coal, oil and natural gas. There are two main problems with the use of fossil fuels. Firstly, by-products of the burning of these fuels, such as carbon dioxide, concentrate in the atmosphere and lead to global warming. Secondly, fossil fuels represent a finite and fast-diminishing natural resource.

The solution to both of these problems is to reduce the reliance on fossil fuels; both by being more energy efficient, and by finding alternative and renewable sources of energy. Although climate change is a global problem, there is a widespread recognition that action taken at the local level has important consequences for global well-being.

Sustainable building design will help to reduce greenhouse gas emissions and enable adaptation to climate change. It is an important step towards Sustainable Development – a statutory duty for local authorities, enshrined within the NPPF. Revisions to UK Building Regulations Part L (energy efficiency) require a 20% improvement in current energy standards in buildings: this has profound implications for design.

Sustainable building design principles should be considered at the beginning of the design process, as some features – such as Passive Solar Design – cannot be retro-fitted. This chapter sets out sustainable building design considerations for the following elements of the design process; site and layout, buildings and building materials.

12.2 A sustainable building is one that:

- minimises the use of scarce resources such as certain building materials, fossil fuels and water;
- is economic to run over its whole life cycle and fits well with the needs of the local community;
- is energy and carbon efficient, designed to minimise energy consumption, with effective insulation, heating and cooling systems and appliances;
- values and sustains or improves existing site character, topography, vegetation, watercourses and built features;
- minimises the need for unsustainable transport and encourages travel by cycle or on foot;
- minimises the production and costs of waste disposal, and which looks to re-use on-site materials such as waste soil;
- minimises flooding and pollution;
- is designed to make recycling and composting easy for its occupants.

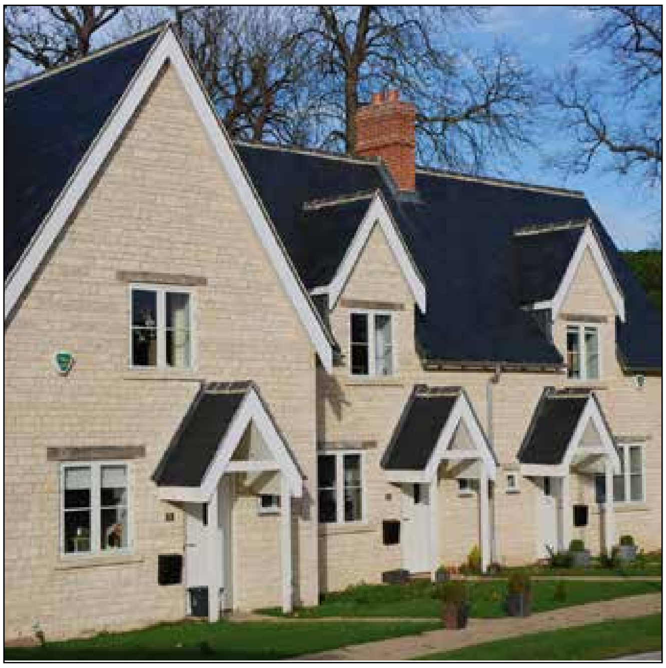


Fig. 1 Modern eco-housing in Bladon

12.3 The site and layout

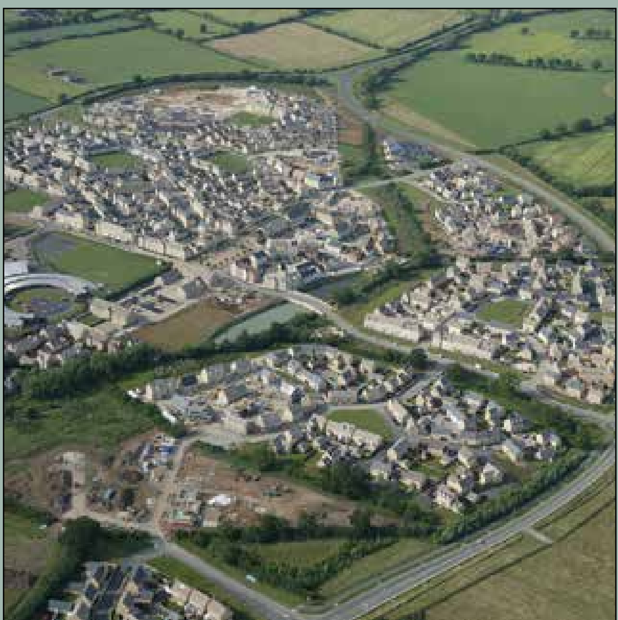
Location and setting

Traditional buildings in the District were generally located in sheltered rather than exposed locations and were thus easier to heat. They were close to primary resources such as water, with easy access to the work of the occupants.

Development in a sustainable location both benefits from and supports existing local services and infrastructure, and is thus less reliant on fossil fuels than is development remote from local services.

The Local Plan embodies the principles of sustainable development by locating most new development in the largest settlements in the District, where the need for travel to local services and infrastructure is minimised. Within development areas, layout design should be as cycle- and pedestrian-friendly as possible, to further encourage reduced reliance on travel by car.

A sustainable development approach is one which values and sustains or improves the character of the site. Existing features, such as topography, vegetation, watercourses and built structure should be retained wherever possible. Inert materials which arise from the development should, in the first instance, be retained and re-used on the site, not disposed of elsewhere.



Energy saving layout design

The siting and orientation of buildings relative to the existing landscape (together with the treatment of that landscape) can save up to 30% in cooling and heating costs. The amount of direct sun heating up surfaces can be reduced, and reflected light prevented from carrying heat into the building from the ground or other surfaces. It can also reduce wind velocity and slow air leakage from the house.

To maximise solar gain, the majority of housing within a layout would need to face within at least 45 degrees of south, and preferably within 30 degrees. Overshadowing by neighbouring buildings and trees should reduce the loss of useful total solar gain by no more than 5% (through the spacing and location of dwellings rather than the loss of existing trees). Maximising solar gain at the layout design stage also maximises the potential for solar power generation (which may be added to the scheme at a later date). In general it is both easiest and most cost-effective to incorporate sustainable energy strategies – such as Combined Heat and Power (CHP) and Geothermal Energy – at the design layout stage.

During summer months, shade created by trees, together with the effect of grass and shrubs, will reduce air temperatures adjoining the house, and provide evaporative cooling. As people may spend more time outside, natural shade becomes more important. Deciduous trees on the south side of a property can be used to admit the winter sun; evergreen plantings on the north side can slow winter winds. Planted channels can funnel cooling summer breezes into a property.

Careful evaluation of existing vegetation will identify those species that can contribute to an energy conserving landscape. Established plants should be retained wherever possible as they will require less effort to maintain, and will generally be larger and better established than new plantings.

See below for detailed information on Passive Solar Design (PSD).

Sustainable landscapes and open space

Increasing average temperatures will lead to a greater demand for outdoor spaces (both public and private) and existing spaces will be used more intensively with lifestyle changes. Although predicting such changes is difficult, the experience of those living in warmer climates can give us some clues.

As outdoor spaces are used more, there will be a need for more hard wearing natural surfaces. Landscaping that mimics Mediterranean marquis or lowland heath land for example can be hard wearing and appropriate to an urban environment. Alternatives to traditional lawns may be needed for hotter, drier summers. Gravelled or paved areas can be used as an alternative to lawn (as long as a high proportion of permeable surfaces – to avoid aggravating soil erosion and run-off – can be provided). However, it should be remembered that lawns are comparatively valuable in biodiversity terms.

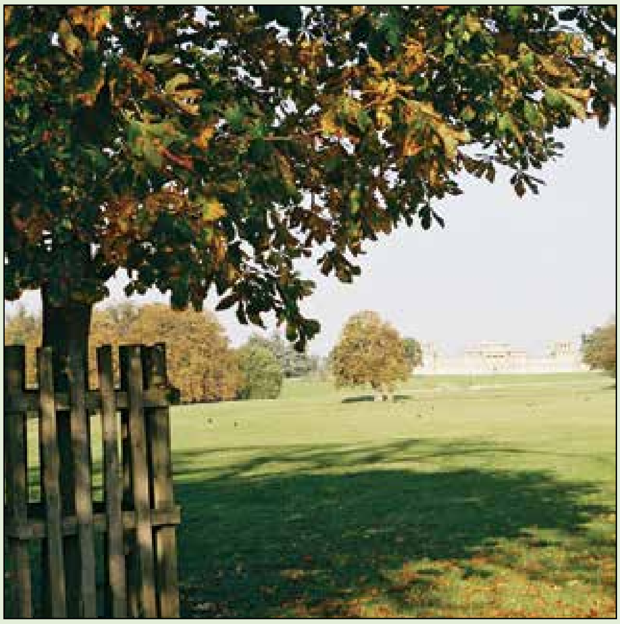
Changes in temperature and water balance can have significant implications for soil, and require the careful planning of green spaces. For example, increased water storage can reduce flooding and subsidence. Other strategies, such as the increased vegetation required for Sustainable Drainage Systems (SUDS) must not be at the expense of soil condition (by for example allowing subsidence).

Adapting to climate change, a landscape checklist:

- Provide deciduous vegetation to give summer shade, taking care that the foundations of nearby buildings are sufficient to prevent movement;
- Introduce soil management strategies to protect against flooding and subsidence;
- Water in water features should be recycled or re-used, for example for watering vegetation rather than putting into drains;
- Solar energy can be used to power pumps to re-circulate water in water features;
- Provide wormeries for compostable waste (although this is only applicable at the domestic scale). Large scale composters could be considered for business/ industrial operations;
- Incorporate an appropriate range of public and private outdoor spaces in developments, with appropriate shade, vegetation and water features;
- Ensure the design of surfaces takes account of increased use, permeability and the potential for causing dust and soil erosion;
- Consider gravelled or paved areas rather than lawns (so long as a high proportion of permeable surface can be provided);
- Ensure the selection of vegetation takes account of future climate change;
- Provide rainwater collection/ grey-water recycling for gardens and landscaped areas.

Biodiversity

Many local plant and animal communities enjoy statutory protection and those found on or adjacent to the site must be conserved at all stages of construction. Planning Conditions, Statute, and Construction Codes and Standards must be adhered to at all times, and damage to trees and contamination or pollution from oil or chemicals must not take place. There is a need not only to conserve biodiversity, but to seek net gains in biodiversity as a result of new development.
See WODG 13: BIODIVERSITY AND PROTECTED SPECIES

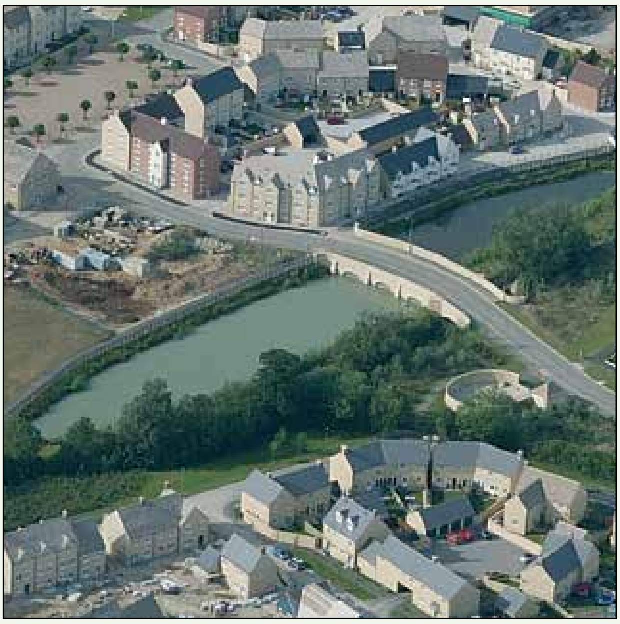


Surface water and Sustainable Drainage Systems (SUDS)

SUDS (sustainable drainage systems) mimic natural drainage patterns and can ease surface water run-off (so encouraging the recharge of groundwater) and can help to avoid soil erosion. SUDS represent a drainage strategy that should be considered on all sites. SUDS include rainwater harvesting, green roofs and water butts; filter strips and swales (vegetated landscape features with smooth surfaces and a gentle downhill gradient to drain water evenly off impermeable surfaces).

SUDS can also provide significant amenity and wildlife enhancements, as well as pollutant trapping and degradation processes (this secondary use must not compromise the system's primary role as a drainage system). Soakaways and permeable and porous pavements avoid aggravating run-off and allow water to drain directly into the ground (though the primary purpose is the conveyance of water away from buildings). In practice, all pavements, driveways, footpaths, car parking areas and access roads could have permeable surfaces.

In 2015 the government published guidance on non-statutory technical standards for SUDS. This can be found at: www.gov.uk/government/publications/sustainable-drainage-systems-non-statutory-technical-standards



Sustainable energy

In the UK five sustainable technologies in particular offer viable alternative means of energy production: Solar, Wind, Ground Source Heat Pumps (GSHP), Biomass and Combined Heat and Power (*CHP)*. The scale and density of a development can have a huge impact on the viability of sustainable energy schemes (for example, CHP schemes are far more viable at higher densities, while biomass systems can be better suited to rural locations). Renewable energy measures should not be taken at the expense of landscape character or the quality of the built environment.

Wind energy

The UK has 40% of Europe's total wind energy, but this is largely untapped and only 0.5% of our electricity requirements are currently generated by wind power. Wind-flow must first be assessed to gauge viability. For planning permission, visual impact – across West Oxfordshire generally, but in the Cotswolds AONB specifically – will form a key environmental consideration.

Ground Source Heat Pumps (GSHP)

Heat pumps transfer heat from the ground into a building (via buried pipework) to provide space heating and, in some cases, to pre-heat domestic hot water. For every unit of electricity used to pump the heat, 3-4 units of heat are produced. Air source and water source heat pumps are also available.

Biomass energy

Biomass is organic matter of recent origin. The CO2 released when energy is generated from it is balanced by that absorbed during the fuel's production. The process is thus carbon-neutral. Biomass is also called 'bio energy' or 'bio fuels'. Bio fuels are produced either directly from plants or indirectly from industrial, commercial, domestic or agricultural products.

Waste and recycling

The Council operates a waste collection service that includes the provision of bins for general waste, food waste and containers for glass, paper, card, plastic and tin. Collection is from the kerbside, but also from communal bin stores or other specified collection points. Waste and recycling provision has profound implications for site layout, and must be considered at an early stage in the design process.

Wormeries for compostable waste can be provided (although this is only applicable at the domestic scale). Large scale composters could be considered for business/ industrial operations. Rainwater collection/ grey water recycling systems can be used for watering gardens and landscaped areas.

Combined Heat and Power (CHP)

With CHP one of the by-products of power generation – namely heat – is recycled for a variety of purposes, including community heating and space heating. Because it uses what is typically waste heat in order to heat buildings it can increase fuel efficiency to 70-90% (compared to the 30-50% with conventional generation). CHP is especially suited to larger community heating schemes.

12.5 The building

Building aspect

Building form, room arrangements and the location of doors and windows in relation to the path of the sun and prevailing winds can have a significant impact on the resources needed for heat and light. For example, a building with its living rooms on the warmer south, south-east or south-west sides could exploit opportunities for large window areas on these walls to maximise natural lighting. By contrast, room functions on the cold and shady north side could take advantage of these conditions for cool storage, services, or to draw in cool air. Window sizes can be smaller on the cold side to reduce heat loss.

The layout of new development should balance the benefits of minimising heat loss in winter with the risk of excessive solar gain during the summer. The site layout should take advantage of landform and landscape for shelter to minimise heat losses in winter and provide adequate shade in summer. For example, deciduous trees help minimise heat loss but also provide shading in summer but lower sun angles permit solar gains in winter.

Passive Solar Design

Passive Solar Design (PSD) makes use of the sun's energy for heating and cooling living spaces. Further information on PSD can be found at: http://www.greenbuilder.com/sourcebook/PassiveSol.html.

In the case of Passive Solar Heating, the goal is to capture the sun's heat within the building's elements and release that heat during periods when the sun is not shining. The principal features of Passive Solar Heating are south facing windows and Thermal Mass.

The building envelope should be designed to benefit from passive heat in winter, but reduce heat gain in the summer. Summer heat gains can be reduced by lighter or more thermally reflective surfaces, especially roofs. Passive Solar Cooling makes use of natural ventilation, and typically employs such elements as openable ventilation windows, wing walls and thermal chimneys.

Openable windows can aid natural ventilation when located in the path of prevailing summer breezes. Wing walls are vertical exterior wall partitions placed perpendicular to adjoining windows, which enhance ventilation through windows. Thermal chimneys create or reinforce the effect of hot air rising, in order to draw air out of buildings and induce air movement for cooling purposes.

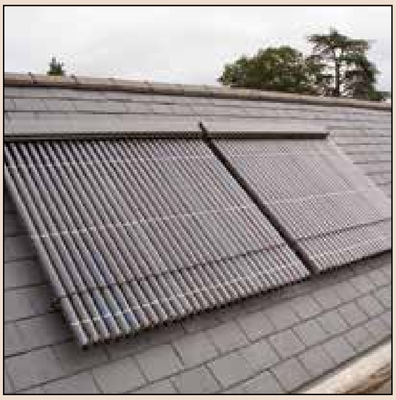
Thermal capacity and insulation

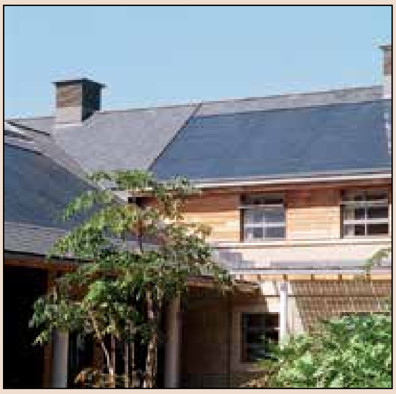
Thermal Mass refers to materials, such as masonry and water, which can store heat energy and be used to prevent rapid temperature fluctuations. Traditional local stone buildings have thick walls of substantial mass and high thermal capacity: they heat up and cool down slowly, insulating the residents from rapid thermal variations. Modern buildings, by contrast, have thin walls and low thermal capacity. To address this, Buildings Regulations require high levels of thermal insulation.

The structure should have the optimum Thermal Mass for a comfortable internal environment with the least use of energy. For high occupancy uses (e.g. houses and hospitals) this usually means high thermal mass. Many types of insulation are made using processes which produce toxic waste and gasses, or are manufactured in other parts of the world, leading to heavy energy use in transportation. It is worth considering local natural insulation, such as wool batts, which are produced from the by-products of textile production.

Solar panels

Despite the UK's cool climate, solar energy still represents a highly viable means of sustainable energy production. The sun's energy can be harnessed in two main ways: by using photovoltaic (PV) panels, which utilise light to produce electricity; or by using solar powered heating panels, which directly heat water. Solar technology is well-established, with a wide range of products on the market. Panels can be linked in almost inexhaustible configurations, and for optimum performance should be located on south-facing, unshaded roof aspects.

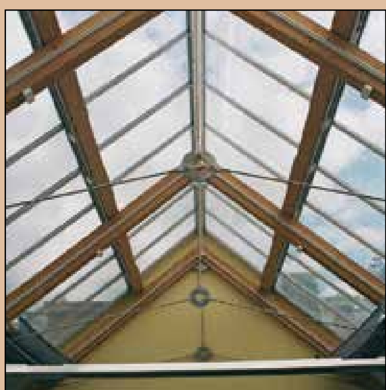




Convection ventilation

Natural processes can be exploited to provide free ventilation. Since hot air rises, cool fresh air may be drawn into a building at low level on the shady side. When heated by solar gain from south facing windows air will be drawn upwards and vented naturally at high level, helping to draw in more fresh air at low level. Atria, conservatories and porches can be used to enable natural ventilation and the conservation of heat.

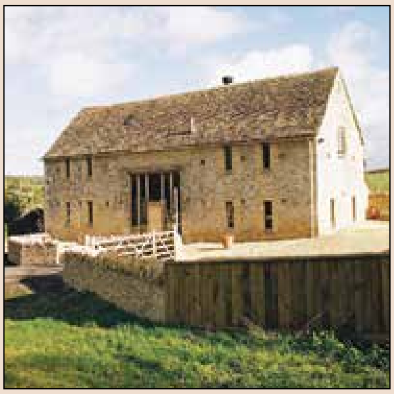
Higher temperatures may lead to pressure for mechanical ventilation and cooling to be added to buildings in the future, even if not installed initially. Developers should consider using alternative methods to traditional air conditioning so that comfortable temperatures can be maintained while minimising additional greenhouse gas emissions. Larger floor-to-ceiling heights will generally help in allowing later addition of any cooling mechanisms. Higher ceilings trap hot air above the heads of people using the room, making the room feel cooler.



Re-use or conversion of existing buildings

The re-use or conversion of existing buildings takes advantage of the high levels of embodied energy in their fabric. This would be lost in demolition and redevelopment; processes which themselves would use even more energy.

It was thought until recently that the embodied energy content of a building was small compared to the energy used in operating the building over its life. Most effort was therefore put into reducing operating energy by improving the energy efficiency of the building envelope. Research has shown, however, that this is not always the case. Embodied energy can be the equivalent of many years of operational energy. Consequently, buildings should be designed for long life and adaptability, using durable, low maintenance and easily separable materials. Avoiding an overly large house will also save materials.



Timber

The UK is currently the largest importer of illegal tropical timber in Europe, with approximately 60% of all UK tropical timber imports coming from illicit logging operations in some of the world's most important rainforests.

Due to an increase in the design of 'green' buildings, and the promotion of timber as a renewable resource, the use of timber within the construction industry is likely to grow. As a result of this increase in demand there is also an increased likelihood of illegal logging, poor forest management and deforestation.

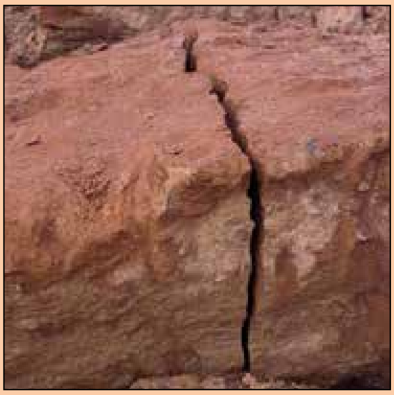
Timber used in construction should be drawn from sustainable sources. The CIOB (Chartered Institute of Building) 'Procuring Legal and Sustainable Timber' guide explains the procedures that need to be adopted by construction organisations to achieve these environmental objectives: www.constructionbooksdirect.com.

Local materials

The use of locally-produced sustainable materials reduces energy use in transport, and promotes local enterprise and employment. By contrast, many cheap products are manufactured in other parts of the world, and because of large energy inputs in transport, cannot be seen as sustainable.

Embodied energy is a method of factoring in all the hidden energy costs of producing a material. This gives a truer cost of the building material. Some general estimates of embodied energy for various materials (the higher the number the higher the environmental 'cost'):

Material	Embodied Energy
Timber	1
Brick	2
Glass	3
Steel	8
Plastic	30
Aluminium	80



Manufactured materials and pollution

Many modern building materials and products are manufactured using very high energy inputs and processes which produce toxic waste and gasses.

PVC is excluded from the EU's and WWF-UK's purchasing policies because it contains phthalates and releases highly toxic chemicals when incinerated. PVC is not a sustainable material and will degrade with exposure to ultraviolet light.

As a general rule, the sustainable designer should avoid materials which emit formaldehyde, organic solvents, VOCs and chloroflourocarbons, which contribute to the recent 'sick' buildings phenomenon.

Most finishes and adhesives contain VOCs which 'outgas' and adversely affect indoor air quality. Lower VOC and non-VOC products are available.

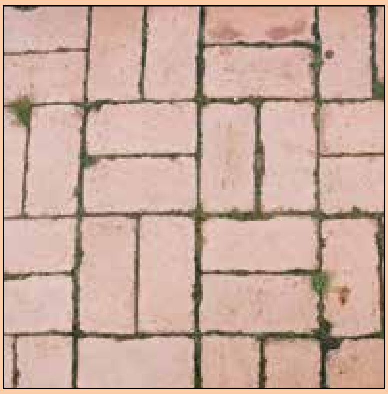
Low biocide paints avoid the fungicides and mildewcides typically added to latex paints to extend their shelf life. These additives are potentially harmful to indoor air quality. Natural plant/mineral-based finishes and adhesives are available from several companies (such products can cost more and can spoil if not used quickly). Some very energy-intensive finishes, such as paints, often have high wastage levels.

Re-use of materials

Efforts should always be made, where possible, to re-use and refurbish rather than demolish or replace. The re-use or recycling of manufactured building materials, such as brick, timber or slate, is highly sustainable because it reduces the strain on natural resources and eliminates the need for new energy investment.

Materials that are local, and that have a high recycled content and low embodied energy should be favoured, and preference given to materials manufactured using renewable energy sources. Standard sizes should be specified; the use of energy-intensive materials as fillers should be avoided; off-cuts, construction waste and materials arising from demolition should be re-used or recycled.

Redundant structure should be avoided, and efficient building envelope design and fittings used in order to minimise materials use. Materials that can be re-used or recycled easily at the end of their lives using existing recycling systems should be favoured.



Water services

The supply of water is likely to become more restricted because of climate change, while the demand is likely to increase.

The use of water from the mains should be minimised. New homes should be built to the highest practicable BREEAM Ecohomes standards with regard to reducing internal water use. Further information can be found at: www.breeam.org/

Strategies to minimise water use include water efficient toilets (and waterless urinals), taps, showers, dishwashers and washing machines, as well as the installation of water re-use systems. Water saving can also be promoted by installing water meters.

Rainwater should be harvested for irrigation, garden watering (in butts), car washing or toilet flushing. Such systems reduce household water demand, ease pressure on the mains water supply, and can reduce the risk of flooding by storing rainwater and buffering run-off.

Targets for water consumption:

Housing - 30 cubic metres per person per year;

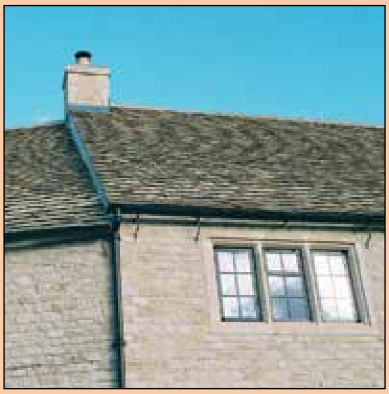
Offices - 1.05 cubic metres per person per year.

Wind and rain

Climate change is likely to result in stronger winds and heavier rain, so roof and local drainage systems must be designed to cope with the increase. Loose items, such as roof tiles, may need to withstand higher winds, while rain may be driven harder against walls and roofs. The design of openings and the choice of materials must allow for this.

The risk of flash-flooding will also increase, while at the same time Building Regulations now require level thresholds for disabled access. Both of these factors increase the risk of ingress of water at ground level.

The size of guttering and down pipes could be increased. The use of secret and parapet gutters and internal down-pipes should be reduced. Water could be thrown clear of buildings using spouts and gargoyles, and storm drains on the ground. In areas of low flood risk, the size of upstands could be increased.



12.7 Help with energy efficiency

Other resources providing information on a range of sustainability issues:

Thames Valley Energy Centre:
www.tvec.org.uk
Wide range of sustainable energy advice and services.

The Energy Saving Trust:
www.energysavingtrust.org.uk
Helpline: 0845 7277200
Practical and money-saving advice, much of it in easily downloadable documents.

Environment Agency:
www.gov.uk/government/organisations/environment-agency
Up-to-date information on the latest government guidelines.

Carbon Trust:
www.carbontrust.com
Research and development into energy efficient buildings.

Defra (Department for Environment, Farming and Rural Affairs):
https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs
Defra environmental protection pages.

Low Carbon Trust:
www.lowcarbon.co.uk
Progressive, detailed advice and information on sustainable building.

Waste and Resources Action Programme:
www.wrap.org.uk
National scheme developing markets in recycled products.

Centre for Alternative Technology:
www.cat.org.uk
Wide-ranging information resource for alternative technologies.

Association for Energy Conscious Building:
www.aecb.net
Founded to increase awareness within the construction industry of the need to respect, protect, preserve and enhance the environment.

Construction Resources:
www.constructionresources.com
Information on construction materials and procurement.

Natural Building Technologies:
www.natural-building.co.uk
Founded to bring ecological building materials and systems into the mainstream construction industry in the UK.

BRE:
www.bre.co.uk
Multi-disciplinary building service centre with a mission to improve the built environment through research and knowledge generation.

National Energy Foundation:
www.nef.org.uk
Charity that gives people, organisations and government the knowledge, support and inspiration they need to understand and improve the use of energy in buildings.

Zero Carbon Hub:
www.zerocarbonhub.org
Provides a range of resources to support the mainstream delivery of low and zero carbon homes in England, including 'Builder's Book' - an illustrated guide to building energy effiient homes.